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REPORT ON
SUBSIDENCE PREDICTION AND MANAGEMENT
CHURI-BENTI UNDERGROUND PROJECT
CENTRAL COALFIELDS LIMITED

MARCH 2009

A. J.
Project Officer
Churi Benti UC Project
N.K. Area, CCL

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MARCH 2009

MINING LABORATORY
CENTRAL MINE PLANNING & DESIGN INSTITUTE LTD.
GONDWANA PLACE, KANKE ROAD
RANCHI - 834 008

Project Officer
Churi Benti UG Project
N.K. Area, CCL

Report on subsidence prediction and management for
Churi-Benti Underground Project, CCL.

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Project Officer
Churi Benti UG Project
N.K. Area CCL

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Project Officer
Churi Benti UG Project
N.K. Area. CCL

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A. J.
Project Officer
Churi Benti UG Project
N.K. Area, CCL

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Project Officer
Churi Benti UG Project
N.K. Area, OCL

1.0 INTRODUCTION :

The Churi-Benti UG project has been formulated for production augmentation of the existing Churi underground mine using low capacity continuous miner. The planned capacity of the project is 0.81 Mtpa.

Two workable coal seams exist within the colliery precincts viz. upper and Lower Bachra . Prior to nationalization, coal was extracted from only a few easily approachable isolated patches of the lower Bachra seam. In post nationalization period however both lower and upper Bachra seams have been developed extensively on Bord & Pillar system. Extraction of pillars was, however, not possible due to surface constraints and difficult geomining conditions. Unfavorable geological conditions of the mine had been interrupting the production target for so long. In this project, the undeveloped part of the Lower Bachra seam of Churi block and the adjoining virgin Bottom Lower Bachra of the Benti block across Damodar river have been identified for introduction of mass production technology using Low Capacity Continuous Miner, and this forms the area of the present study. In this part of the mine immediate liquidation of the lower Bachra seam is feasible, because the overlying upper Bachra seam is unworkable for inadequate thickness. This part of the mine where the continuous miner will be engaged has been named as Churi Reorganization Project.

In the selected property, as the working depth is less than 100 m and the extraction height above 4 m, it is obvious that the magnitude of subsidence would be high. Thus manifestation of subsidence at surface would immediately follow the main fall of roof in goaf, and the troughs & ridges so formed at surface would precisely over lay the voids and pillars of underground. While the first two features are uncongenial for surface stability, the third feature helps better implementation of the subsidence mitigative measures through predictional and planning accuracy.

The land use data of the colliery indicates that out of 244.60 Ha of the surface area, 229.10 Ha belongs to forest-land category. The Damodar and its tributaries, high ways, power lines and a few habitats are amongst the other surface constraints. To evaluate the damage potential of subsidence on these surface features and to suggest mitigative measures, an estimate of subsidence has been made in this study

A. J.
Project Officer
Churi Benti UG Project
N.K. Area, CCL

by using a computer based numerical modeling technique designed on Influence Function method.

This subsidence prediction report presents all details about formation of subsidence troughs, location of maximum subsidence, and disposition of tensile zones along periphery of each trough. The damage prone areas at the surface, exhibiting either differential settlement of land or formation of tensile cracks, have been demarcated from these subsidence related parameters and shown on different surface plans. Suitable subsidence management scheme and mitigative measures have also been presented in the report to accommodate the anticipated post-mining effects.

This report on subsidence prediction is intended to form a part of EMP.

2.0 DETAILS OF THE PROJECT :

- 2.1 Name of the Mine : Churi-Benti Underground Project
- 2.2 Area : North Karanpura
- 2.3 Company : Central Coalfields Limited
- 2.4 Geological Reserve: 36.20 MT(for Churi Block) and 8.70 MT(for BLB Seam of Benti Block)
- 2.5 Extractable reserves: 3.21 MT (Churi Block) and 1.01MT for CM deployment (Benti Block)
- 2.6 Details of the coal seams being worked :

Block	Section	Panels	Seam	Thickness	Depth	Remarks
Churi	Western	H1 to W15	Lr. Bachra (Comb)	Generally 3.0 to 5.0m	21.59 to 93.65m	Unworkable to virgin upper Bachra Seam
	Eastern	E12 & E13	-do-	-do-	-do-	Up. Bachra developed
Benti	Adjacent eastern	B5 to B9	Lr. Bachra (Bot)	Upto 4.25m	76.27 to 121.68m	Up. Bachra not developed

- 2.7 Proposed Method of Extraction : Bord & Pillar with caving using continuous miner
- 2.8 Anticipated Percentage of Extraction in Panels : 75%

- 2.9 Overlying Rock Mass : Mostly composed of fine to coarse grained sandstone, sandy shale, carbonaceous shale, grey shale, conglomerate and intercalation of shale & sandstone.
- 2.10 Size of Panels : Most panels are sub-critical and some are super-critical.
- 2.11 Expected Life of the : 11 years
CM panels
- 2.12 Surface Topography : The surface topography of mining area is uneven. The ground elevation ranging from 404.50 to 476.80m above MSL..
- 2.13 Present Land Use : Major area is forest and remaining is tenancy land.
- 2.14 Surface Properties and : Damodar and Saphi rivers, nallas, PWD
their Protection roads, surface structures, HT lines, forest & tenancy land. PWD roads and rivers are proposed to be protected by leaving sufficient solid coal pillars/barrier against them. .

3.0 TOPOGRAPHY, DRAINAGE AND LAND USE :

Churi-Benti underground project is situated in the south-central part of the North Karanpura coalfield of CCL. The project covers an area of 5.89 sq km of Churi block and 1.79 sq km of Benti block., with Damodar river flowing along the common boundary separating the two blocks. The area considered for application of continuous miner, which concerns this study, is however 2.03 sq km of Churi and 0.41 sq km of Benti block .

The topography of the area is gently undulating with elevations varying from 404.50 to 476.80 m above MSL. The general slope of ground trends towards Saphi and Damodar river. The western part of the block is hilly with ridges rising upto 529.74 m above MSL.

The Churi-Benti block as a whole is under a forest cover. Out of the total area of 244 Ha, forest occupies 229.10 Ha. Damodar river with a few seasonal tributaries, villages, high ways and power trestles constitutes the surface features.

4.0 GEOLOGY :

The stratigraphic sequence of North Karanpura coalfield is defined as follows. The coal seams of Churi-Benti block belong to The Karharbari formation.

Table 1: Stratigraphy of North Karanpura Coalfield

Geological Age	Group	Formation	Remarks
Permian	Ur Gondwana	Mahadeva	
		Panchet	
	Lr Gondwana	Ranigunj	
		Barren Measure	
		Barakar	OB of Churi-benti block
		Karharbari	Seams of churi- Benti block
		Talchir	
----- Unconformity -----			
Pre-cambrian	Metamorphic Basement		

The Stratigraphic succession of Churi- Benti block is as follows. It can be seen that there are only two persistent coal seams in the block- Upper Bachra and lower Bachra. These seams are separated by a parting varying in thickness from 0.49 to 20.27 m. The strata overlying upper bachra seam comprises Karharbari sediments upto 47.42 m and rest belongs to Barakars.

Table 2: Stratigraphic Sequence in Churi Block

Formation	Lithology of strata/ Coal seams	Thickness, m
Recent	Soil	0.23 to 12.20
Barakar	Conglomerate, sandstone (sst), shale (sh), intercalated sh & sst, fire clay.	30.03 to 84.61
Karhar bari	Sst, sh, conglomerate and fire clay	20.22 to 47.42
	Upper Bachra Seam	0.13 to 4.84
	Parting- sst, sh and Intercalation of sst & sh	0.49 to 20.27
	Lower Bachra Seam	1.71 to 11.24
	Sst and sh	Not drilled
Talchir	Khanki green sst, sh and boulder bed	Not drilled

Coal Seams:

Coal seams of Karharbari formation are characterized by their 'split & merged' nature of disposition. The formation is also associated with thinning & thickening of seams and variation of parting thickness.

In Churi-Benti block there exists two coal seams only, viz. Upper Bachra and Lower Bachra seams. Both the seams belong to Karharbari formation. In the continuous miner (CM) section of the block, which forms the locale of the study, the upper Bachra seam is not developed to workable thickness. Thus there is only the lower Bachra seam in study area. This lower Bachra seam in Churi block appears as a single seam, while the same seam splits into three sections in the adjoining Benti block. It is only the bottom split which is workable in Benti block.

The details of lower Bachra seam in CM section of Churi-Benti project is furnished in Table 3.

Table 3: Lower Bachra seam in Churi-Benti CM Block

Block	Section	Panels	Seam	Thickness	Depth	Remarks
Churi	Western Section	W-1 to W-15	Lr. Bachra (comb)	Generally 3.0 to 5.0 m	21.59 to 93.65	Up. Bachra unworkable & virgin
	Eastern Section	E-12 & E-13	-do-	-do-	-do-	Up. Bachra developed
Benti	Adjacent Eastern Section	B-5 to B9	Lr. Bachra (bot)	Up to 4.25 m	76.27 to 121.68	Up. Bachra not developed

Strike & Dip:

In Churi block strike of the coal seam trends towards NE-SW over major part of the property. It swings gradually to N-S on eastern part. The dip of strata varies between 2 to 3 degrees toward west.

In Benti block, it being on the limb of a plunging anticline, the strike of strata changes greatly from N-S to E-W with a westerly dip of 1 to 3 degrees.

Low seam gradient keeps the subsidence axis vertical and protects the geometrical symmetry of the subsidence trough as per prediction.

Faults:

The area under consideration lies between two major fault planes F10 & F17 along its northeastern and southwestern boundary respectively (plate 2). These fault planes because of their dipping towards the workings may drag the angle of draw outward stretching the subsidence trough along NE-SW up to the fault out-crop at the surface. Other randomly oriented faults within the property would influence development of the trough locally.

5.0 METHOD OF MINING :

The Continuous Miner will be deployed initially in Benti block for development & depillaring of the virgin reserves in panels B5 to B9 & T1. Subsequently, it will be shifted to Churi block for depillaring of panels W1 to W15 in the western section and panel E12 & E13 in the eastern section under Churi Re-organisation (CRO) programme. In both the blocks the minimum & maximum height of extraction in the continuous miner section would be 3.0m to 4.6m, and depillaring will be associated with caving of roof in goaf.

The mine layout plan of Churi-Benti block is shown in Plate 1, and the panels proposed to be depillared by Continuous Miner in Plate 2. These layout plans have been obtained from the underground working plan of LBS-BLB seams of Churi-Benti Project as supplied by CMPDI, RI-III.

6.0 SUBSIDENCE PREDICTION :

The subsidence prediction model based on Influence Function method, developed in CMPDI, has been used for estimation of likely subsidence over the mining area. Subsidence prediction has been done only for the panels proposed to be depillared by caving method using continuous miner as per the mine projection plan LBS-BLB of Churi-Benti Project.

The details of mine layout, surface contours, surface features, forest and other relevant features have been digitised from surface plan and layout plan of LBS-BLB of Churi-Benti project. These digitised data have been used as input parameters for the subsidence prediction model. All other input data regarding the thickness of extraction, depth of panels etc have been collected either from the project report or from the plans supplied by CMPDI, RI-III. The site specific subsidence parameters e.g. subsidence factor, angle of draw, non-effective width of the panels, etc., to be used in the subsidence model, were not available for the mine. These values have been obtained from subsidence data observed in near by mines and from other coalfields having similar geo-mining conditions.

The parameters taken for subsidence prediction are as follows :

- i) Subsidence factor : 0.43 for single seam extraction.
- ii) Angle of draw : 30°
- iii) Anticipated percentage : 75%
of extraction in panels
- iv) Depth : Average depth of each panel
- v) Non-effective width : $0.3h$ where "h" is average depth of each panel.
of the panels
- vi) Thickness of extraction : Average thickness of the seam in each panel or
maximum of 4.6m

Before subsidence prediction, the prediction model has been calibrated using the above mentioned input parameters. For subsidence calculation, underground extraction area has been divided into 20m x 20m grid blocks as individual elements. The numerical procedure followed for prediction involves estimation of subsidence at the grid points of each element and subsequently, by integration, the resultant values and the final area of influence of ground movement estimated. Subsidence has been calculated over 22,500 such grid points.

Subsidence prediction has been made separately for each panel in LBS-BLB seams. Panels proposed for extraction in Churi Block and those in Benti Block have been shown in blue and pink colours respectively in Plate 2.

6.1 LIMITATIONS:

The depth of extraction in Churi-Benti CM block varies from 22 to 122m. For depths up to 60m, formation of pot-holes over wide gallery junctions, as are formed during development with continuous miner cannot be eliminated. This would call for site specific roof support design.

7.0 SUBSIDENCE PREDICTION RESULTS :

7.1 Maximum subsidence, subsidence contours and subsidence profile

The anticipated maximum subsidence over the mining area due to extraction of Continuous Miner panels is 1.978m. subsidence of this magnitude is likely to

occur over the panels W5, W9, W10, W12, W13, E12 and E13. Incidentally, all these panels lie under forest cover.

From the estimated subsidence at each grid point, subsidence contours at 0.4m interval are drawn for depillaring of the Continuous Miner panels as shown in Plate 4. Subsidence contours are shown alternately in violet and orange colours.

The final stage subsidence profile along line AA' has been shown in Plate 9.

7.2 Effect of subsidence on surface topography and surface features along with mitigative measures :

Surface topography before mining and at the end of extraction of CM panels are shown in Plates 3 & 5. Change in topography due to subsidence can be seen by comparing the above mentioned plates. For assessment of change in ground condition before and after mining, 3D views of surface topography before and after mining are also shown in Plates 6 & 7. By comparing these 3D views, it is observed that there is a moderate change in surface topography. The surface profile before mining and after final subsidence along line AA' is shown in Plate 9.

The topography of the mining area is gently undulating and sloping towards Saphi and Damodar river with elevation varying from 404.50 to 476.80 m above MSL i.e. a difference in elevation of 72.30m. For such a terrain, the maximum anticipated subsidence of 1.978m is unlikely to affect the overall drainage pattern in the area. It can only result in formation of isolated depressions over the centre of the panels with tensile cracks in zones of high tensile strain along the periphery. Pools of water are likely to be formed in these depressions during rains, which may be retained for the benefit of vegetation in the forest land. Wherever necessary some of these depressions may have to be filled or drained out by cutting drains to ensure safety of underground workings. The surface cracks, developed due to subsidence, need to be filled up regularly and properly with clay and stone chips to retain the original drainage run off of the area and also to prevent ingress of air and water into the underlying goaf. This will minimise the chances of underground inundation and spontaneous heating.

For estimating the effects of subsidence on surface features, panel wise anticipated maximum subsidence, slope and tensile strain have been calculated for

Subsidence Prediction of Churi- Benti Project

extraction of each CM panel in Churi-Benti Project and shown in Table 5. Tensile strain at the surface developed due to subsidence of strata is considered as the prime cause of damage of the surface features. The magnitude of likely strain near the important surface features have been used to envisage the extent of damages to the surface features.

The impact of subsidence on different surface features are outlined below.

Impact of subsidence on roads :

A PWD road passing through the mining area is unlikely to be affected by subsidence because sufficient coal pillars are proposed to be left unextracted vertically below and within 45m from the road. The other ordinary roads in the area are located outside the subsidence influence zones and are unlikely to be damaged by subsidence.

Impact of subsidence on rivers and nallas :

HFL of Damodar river flowing over the mining area is unlikely to be affected by subsidence because a barrier comprising of solid coal pillars within 60m are proposed to be left un-extracted against the HFL of Damodar river. Saphi river is distant from subsidence influence area, therefore it is not likely to be affected by subsidence.

Small nallas flowing through the mid area of CM panels of Churi Block are, however, anticipated to be affected by a maximum amount of 1.91m subsidence, 47.16mm/m slope and 24.76 mm/m strain. These essentially need to be protected by leaving coal pillars unextracted vertically below and within 60m distance from these nallas.

Impact of subsidence on HT lines :

The HT lines over the property are likely to be affected by a maximum subsidence of 1.526m and 16.87mm/m tensile strain. The impact of subsidence on the pylons of HT line will depend on the nature of construction of pylons. However, with the anticipated value of subsidence these pylons are likely to be tilted or dislodged. The HT lines should therefore be diverted away from the subsidence influence area or the pylons protected by leaving coal pillars un-extracted vertically below and within 30° angle of draw.

Impact of subsidence on surface structures or built up areas :

Surface structures and built up areas are unlikely to be affected by subsidence as these are situated outside the subsidence influence zone. However, as a protection of the Piparwar rehabilitation site, it is proposed to leave a barrier of 45m in panel B5.

Impact of subsidence on tenancy land :

The tenancy land over the mining area is likely to be affected by subsidence of different magnitude. If any cultivation is done in such subsidence affected areas, crop compensation may have to be paid to the tenancy land owners during the year when depillaring operations are carried out in the panels below it. Reclamation of land by filling and consolidation may also be required at places.

7.3 Effect of subsidence on forest land with mitigative measures :

In Churi-Benti block incidentally almost all the CM panels are located below the forest land. The forest land likely to be affected by subsidence is shown in Plate 4. For estimation of effect of subsidence on forest, panel-wise magnitude of subsidence, slope and tensile strain have been estimated in this study for extraction of each continuous miner panel of the project. The results have been furnished in Table 4.

From the data set it can be seen that the maximum possible subsidence likely to occur in forest area is 1.978m. The associated maximum slope and tensile strain in the same area would be 54.94 mm/m and 28.85 mm/m respectively. The maximum subsidence and the associated values of strain & slope is likely to develop over the panel E13.

Slopes ranging upto 54.94 mm/m, resulting in a tilt of 3.1° , in the forest area may not cause any extensive fall of trees in the forest. Only a limited number of trees situated at the edges of subsidence troughs or around the surface cracks may get tilted or dislodged. The presence of soil cover would further act as a cushion to absorb a portion of surface strain and reduce damage to the forest cover. But it is to be noted from the data that in many places in the forest area the values of tensile strain exceeds the limit of 10mm/m as prescribed by MOEF for the purpose of Net Present Value.

As per recommendation of MOEF, the area in the forest having more than 10mm/m strain would be considered as subsidence affected area due to underground mining and accordingly NPV is to be paid. In this regard the areas likely to be affected by surface strain of 10mm/m or more are shown in Plate 8.

Some provision is also required for compensatory afforestation and strengthening of forest cover to take care of losses.

The surface cracks developed from tensile strain of 28.85 mm/m are likely to have aperture as wide as 300mm or more. All perceptible cracks should be filled up by clay and stone chips with 0.3m high clay heaps over the cracks.

8.0 SUBSIDENCE MANAGEMENT :

Considering the impact of subsidence on surface topography, forest and surface features, as explained in earlier chapters, the following subsidence management aspects are required to be undertaken to overcome or to minimise adverse effects.

- i) Surface cracks likely to develop due to subsidence over the mining area need to be filled up properly and regularly by clay and stone chips, and thereafter with about 0.3m high clay heap over the cracks. It will help in retaining the original drainage pattern & run-off over the mining area, improving the water retention capacity of the soil, minimising top soil erosion and chances of underground inundation and spontaneous heating.
- ii) A team may be formed by the mine management which will be responsible for the proper and regular filling of surface cracks developed due to subsidence. The team will also maintain records of the development and filling of surface cracks. Adequate supply of filling materials should be arranged by mine management at the site.
- iii) Provision has to be made for compensatory afforestation and strengthening of forest cover to take care of losses, if any.
- iv) Subsidence may result in depressions on the surface with accumulation of water during the rains. Such accumulation of water may be beneficial for vegetation in the forest. These water bodies may be retained wherever

possible or drained out by cutting drains depending on safety of the underground workings.

- v) Surface drains should be made outside of the subsidence influence area to prevent the surface water of adjoining area from coming into active subsidence area.
- vi) Coal pillars are to be left unextracted in areas vertically below and within 45m from PWD roads and 60m from river which need to be protected from subsidence.
- vii) Considering the make of water in small seasonal nallas existing over the mining area, due care has to be undertaken while extraction is made below these nallas such as avoiding extraction during monsoon and filling of cracks developed in the bed of the nallas, when dry. However, if it is required to keep the nallas totally out of subsidence influence area, coal pillars should be left un-extracted vertically below and within 60m from these nallas..
- viii) Tenancy lands/non-forest land over the mining area are likely to be affected by subsidence. Compensation should therefore be made to the land owners during the year when depillaring operations are carried out in the panels below it and subsequent reclamation by filling and consolidation of the land.

The impact of subsidence on different surface features and forest land along with the degree of damage are provided in Annexure I for reference. The Subsidence Impact Matrix (SIM) shown therein was developed under a S&T project funded by Ministry of Coal.

9.0 CONCLUSION :

The panel layout and the extraction plan of the continuous miner panels as proposed in the project report of Churi-Benti Reorganise Programme has been considered for prediction of subsidence and numerical estimation of subsidence related parameters. A computer based numerical software developed in CMPDI on influence function method has been used for this subsidence prediction

study. The result of this modelling study inter-alia with the mining programme can be summarised as follows.

- i) The anticipated maximum subsidence over the mining area due to extraction of Continuous Miner panels is 1.978m. Subsidence of this magnitude is likely to occur over the panels W5, W9, W10, W12, W13, E12 and E13. Associated maximum slope and tensile strain of around 54.94 mm/m and 28.85 mm/m respectively would develop over the panel E13.
- ii) In Churi-Benti block incidentally almost all the CM panels are located below the forest land. The maximum possible subsidence in forest areas is likely to be 1.978m. Associated maximum slope and tensile strain in such areas would be 54.94 mm/m and 28.85 mm/m respectively. Maximum subsidence and associated values of strain & slope would develop over the panel E13. Slopes ranging upto 54.94 mm/m causing a tilt of 3.1° in the forest areas would not however cause any extensive fall of trees in the forest. Only a limited number of trees situated at the edges of subsidence troughs or around the surface cracks may get tilted or dislodged. However, many places in the forest area the values of tensile strain may exceed the limit of 10mm/m as prescribed by MOEF for the purpose of Net Present Value. As per recommendation of MOEF, the area in the forest having more than 10mm/m strain would be considered as subsidence affected area due to underground mining and accordingly NPV is to be paid. In this regard the areas likely to be affected by surface strain of 10mm/m or more are shown in Plate 8.
Surface cracks developed from tensile strain of 28.85 mm/m are likely to have aperture as wide as 300mm or more. All perceptible cracks should be filled up by clay and stone chips with 0.3m high clay heaps over the cracks. Provision for compensatory afforestation and strengthening of forest cover may also be kept to take care of undue losses.
- iii) The PWD road passing through the mining area is unlikely to be affected by subsidence. Coal pillars proposed to be left unextracted vertically below and within 45m from the road would protect the PWD road. The ordinary roads of the area are also unlikely to be damaged because these are located outside the subsidence influence area.

iv) Damodar river with its HFL flowing over the mining area is unlikely to be affected by subsidence because a barrier comprising of solid coal pillars within 60m is proposed to be left unextracted against the HFL of Damodar river. Saphi river too is far away from subsidence influence area. Small nallas lying in the mid property of CM panels of Churi Block is however anticipated to be affected by a maximum amount of 1.910m subsidence, 47.16mm/m slope and 24.76 mm/m strain. These are essentially required to be protected by leaving coal pillars unextracted vertically below and within 60m distance from these nallas..

v) The HT lines over the property are likely to be affected by a maximum subsidence of 1.526m and tensile strain of 16.87 mm/m. The impact of subsidence on the pylons of HT line will depend on the nature of construction of pylons. However, pylons are likely to be tilted or dislodged. It is recommended to divert the HT lines away from the subsidence influence area or their pylons protected by leaving coal pillars unextracted vertically below and within angle of draw of 30° from them.

vi) The built up areas and other surface structures are situated outside the subsidence influence zones and hence would not be affected by subsidence. The Piparwar rehabilitation site is not likely to be affected by subsidence because solid coal pillars are proposed to be left unextracted vertically below and within angle of draw of 30° in panel B5.

vii) The tenancy land over the mining area is likely to be affected by subsidence of different magnitude. If any cultivation is done in such subsidence affected areas, crop compensation may have to be paid to the tenancy land owners during the year when depillaring operations are carried out in the panels below them. Reclamation of land by filling and consolidation may be required at places.

viii) The topography of the mining area is gently undulating and sloping towards Saphi and Damodar river with elevation varying from 404.50 to 476.80 m above MSL. For such a terrain, the anticipated maximum subsidence of 1.978m is unlikely to affect the overall drainage pattern in the area. It can only result in formation of isolated depressions over the centre of the panels. Pools of water are likely to be formed in these depressions during rains, which may be retained for the benefit of vegetation in the forest land or filled up.

Surface cracks formed due to subsidence will need to be filled up with clay and stone chips and thereafter with about 0.3m high clay heap over the cracks. It will help in achieving the original drainage pattern in the mining area, improving water retention capacity of the soil, minimising top soil erosion and avoiding chances of underground inundation and spontaneous heating.

Surface drains should be made outside of the subsidence influence area to prevent the surface water of adjoining area from coming into active subsidence area.

It is recommended that during depillaring close subsidence monitoring should be done over some initial panels for field validation. In view of the high subsidence potential of the area monitoring of subsidence along with mitigative measures is also recommended for specified localities.

ix) It is suggested that the mine management forms a team that will be responsible for the proper and regular filling of surface cracks developed due to subsidence. The team will also maintain a record of the development and filling of surface cracks. Adequate supply of filling material should be arranged by the mine management at the site.

As per computer based numerical modelling study the above considerations should be kept in mind while extraction of the proposed continuous miner panels of Churi-Benti Project is done with subsidence mitigation measures being followed closely.

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CHURI-BENTI UNDERGROUND PROJECT , CCL

Table 4 : Anticipated maximum possible subsidence, slope and tensile strain over mining area after extraction of CM panels of LBS-BLB seams in Churi-Benti Project.

Panel No.	Av. Width	Av. Depth	Extraction Thickness	Max. Subsidence	Max. Slope	Max. Tensile Strain	Likely width of surface cracks
	(m)	(m)	(m)	(mm)	(mm/m)	(mm/m)	(mm)
W1A	56	85	4.4	1050	24.70	12.97	<100
W1	60	83	4.6	1150	27.71	14.55	<150
W2	66	87	4.6	1160	26.67	13.33	<150
W3	128	90	4.6	1970	43.78	22.98	>300
W4	120	91	4.6	1940	42.64	22.38	>300
W5	130	87	4.6	1978	45.47	23.87	>300
W6	130	90	4.6	1970	43.78	22.98	>300
W7A	98	95	4.6	1660	34.95	18.35	<300
W7B	80	95	4.6	1260	26.52	13.93	<150
W8A	80	84	4.6	1470	35.00	18.38	<300
W8B	125	84	4.6	1970	46.90	24.63	>300
W9	120	81	4.6	1978	48.84	25.64	>300
W10	130	90	4.6	1978	43.96	23.08	>300
W11	120	98	4.6	1930	39.39	20.68	>300
W12	148	86	4.6	1978	46.00	24.15	>300
W13	148	95	4.6	1978	41.64	21.86	>300
W14	125	85	4.6	1970	46.35	24.34	>300
W14A	125	87	4.6	1930	44.37	23.29	>300
W15	130	92	4.6	1970	42.83	22.48	>300
E12	124	76	4.6	1978	52.05	27.33	>300
E13	120	72	4.6	1978	54.94	28.85	>300
B5	100	90	3.4	1380	30.67	16.10	<200
T1	100	90	3.5	1370	30.44	15.98	<200
B6	80	87	4.0	740	17.01	8.93	<50
B7	96	83	4.0	1640	39.52	20.75	>300
B8	100	80	4.0	1690	42.25	22.18	>300
B9	100	83	4.0	1650	39.76	20.87	>300

Note: All the panels are below the forest land.

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SUBSIDENCE IMPACTS

The Subsidence Impact Matrix given below shows the degrees of damage for various surface features, including forest land, vis-a-vis subsidence, slope and strain values was developed as part of a Ministry of Coal funded S&T project and is extracted from the S&T Report titled "Subsidence in Mining Areas" by CMRI.

Sl. No.	Impact	Subsidence	Slope	Strain
		mm	mm/m	mm/m
1	2	3	4	5
<u>SURFACE TOPOGRAPHY</u>				
1.	Practically no impact	<500	<3	<3
2.	Some fine cracks or one or two 50mm wide cracks with visible depression	<500 500-1000	3-5 5-10	3-5 3-5
3.	A large number of fine cracks or a few 100mm wide cracks with marked depression	500-2000	10-20	5-10
4.	A large number of 50-100mm wide cracks or a few 200mm wide cracks with stepping. Marked distortion in surface topography	500-2000	>20	10-20
5.	500mm wide cracks with stepping and prominent distortion in surface topography	>1000	>50	20-50
6.	Many 500mm wide cracks some upto 1000mm width, large stepping. Severe distortion in surface topography	>2000	>100	50-100
7.	Very severe distortion in surface topography. Stepped subsidence with very wide cracks.	>2000	>100	>100

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1	2	3	4	5
		mm	mm/m	mm/m
<u>SURFACE WATER BODIES</u> (Ponds, Rivers, Nallahs, Jores, HFL)				
1.	Practically no impact. No loss of water	<500	<3	<3
2.	Marginal impact in some cases only. Some loss of water and water logging	<1000	<5	<5
3.	Severe impacts. Major loss of water. Severe water logging	>1000	>5	>5
<u>SUB-SURFACE WATER TABLE</u>				
1.	Marginal depletion in water retaining capacity	<500	<3	<3
2.	Severe depletion in water retaining capacity	-	-	>5
<u>AQUIFERS</u>				
1.	Depletion in water retaining capacity	-	-	>3
<u>WATERLOGGING ON SURFACE</u>				
1.	Very little waterlogging	<500	-	-
2.	Some (300-500mm deep depending on surface topography)	500-1000	-	-
3.	Marked waterlogging	>1000	-	-
<u>ROADS</u>				
1.	Practically no impact	<500	<5	-
2.	Depressions with gentle slope	-	5-10	-
3.	Steeper slopes (speed restriction may be necessary)	-	20-50	-
4.	Marginal repairs necessary	-	20-50	>10
5.	Major repairs necessary	-	>50	>10

Subsidence Prediction of Churi-Benti Project		CMPDI		
1	2	3 mm	4 mm/m	5 mm/m
RAILWAY LINES - JOINTED CONSTRUCTION				
1.	Practically no impact	-	<10	<3
2.	Minor to severe impacts, repairs necessary due to bending twisting and breaking of rails and steeper gradients	-	>10	>3
RAILWAY LINES - WELDED CONSTRUCTION				
1.	No subsidence permitted. Even very small strain can cause twisting and breaking of rails,			
RAILWAY SIDINGS (Jointed Construction)				
1.	Practically no impacts	-	<10	<3
2.	Minor to severe impacts, repairs necessary	-	>10	>3
SINGLE STORY HUTMENTS (Kuccha)				
1.	Practically no impact. A few fine cracks in plastered walls	-	<5	<3
2.	Minor repairable impacts. Fine cracks. A few 10mm wide cracks.	-	<10	3-5
3.	Major/severe impacts. Wide cracks, stepping, tilting	-	>10	>5
SINGLE STORY BUILDINGS				
1.	Very little impact. A few fine cracks or one/two 5-10mm wide crack in plaster	-	<5	<3
2.	Minor impacts, repairable. 5-10mm wide cracks, doors and windows getting slight jamming, slight tilting.	-	5-10	3-5
3.	Severe impacts, major repairs necessary. Wider cracks, stepping, crushing and marked tilting.	-	>10	>5

Subsidence Prediction of Churi-Benti Project

CMPDI

1	2	3	4	5
		mm	mm/m	mm/m
<u>DOUBLE STORY BUILDINGS</u>				
1.	Very little impact. A few fine cracks or one/two 5-10mm wide cracks	-	<5	<3
2.	Little repairable impact, 5-10mm wide cracks, slight displacement of walls against roof, doors and windows getting slightly jammed.	-	5-10	3-5
3.	Severe impacts, major repair necessary. Wider cracks, stepping, crushing and tilting. Gaps between walls and roof.	-	>10	>5
<u>MULTI-STORY BUILDINGS</u>				
1.	Little impacts, repairable 5-10mm wide cracks, doors and windows getting slight jamming, displacement of walls against roof.	-	<5	<3
2.	Severe impacts. Wider cracks, crushing, tilting, and stepping.	-	>5	>3
<u>LARGE BUILDINGS, MOVEMENTS, HISTORICAL BUILDINGS, ETC.</u>				
1.	Very little impact. A few fine cracks or one/two 5-10mm wide cracks	-	<3	<1.5
2.	Little impact, 5-10mm wide cracks, Damage to decorations; slight displacements; doors and windows getting jammed.	-	3-5	1.5-3
3.	Severe impacts. Wider cracks, tilting, crushing, etc. Major repairs necessary.	-	>5	>3
<u>AERIAL ROPEWAYS</u>				
1.	Practically no impact	-	<5	<3
2.	Little repairable impacts	-	5-10	3-5
3.	Severe impacts. Ropes may leave pullies due to change in alignment. Tilting of pylons. Buckling of structure.	-	>10	>5
<u>HIGH TENSION PYLONS</u>				
1.	Practically no impact	-	<5	<3
2.	Severe impacts. Tilting, buckling and may be collapse of pylons	-	>5	>3

Subsidence Prediction of Churi-Benti Project		CMPDI		
1	2	3	4	5
		mm	mm/m	mm/m
UNDERGROUND CABLES				
1.	Practically no impact	-	-	<3
2.	Severe impacts (cables may break due to tension).	-	-	>3
UNDERGROUND PIPELINES				
1.	Practically no impact	-	-	<1.5
2.	Severe impacts. Breaking of pipes	-	-	>1.5
OVERLYING VIRGIN SEAMS				
1.	Practically no impact. No visible signs of subsidence when the seams are developed.	-	<5	<3
2.	A little impact. A little crushing of coal, roof and floor rock. Fire risk when development is done in upper seam.	-	5-10	3-5
3.	Severe impacts. Crushing of coal, roof and floor rock. Stepping in tensile strain zone. Fire risk. Heaving, supports necessary during development.	-	10-20	5-10
4.	Very severe impacts. Severe crushing, large stepping, entry into subsided area rather difficult. High fire risk. Arching necessary.	-	>20	>10
OVERLYING WORKINGS (Standing on developed pillars)				
1.	Practically no impact on galleries and pillars. Some spalling.	-	<5	<3
2.	Visible floor lifting, side spalling and roof falls. Supports required. Fire risk.	-	-	3-5
3.	Marked floor lifting, side spalling and roof falls. High fire risks. Workings unsafe.	-	-	5-10
4.	Severe floor lifting, large roof falls, wide spread side spalling, stepping, very high fire risk, workings unsafe.	-	-	>10
OVERLYING WORKINGS (Standing on reduced pillars)				
1.	Practically no impact.	-	<3	<1.5

Subsidence Prediction of Churi-Benti Project

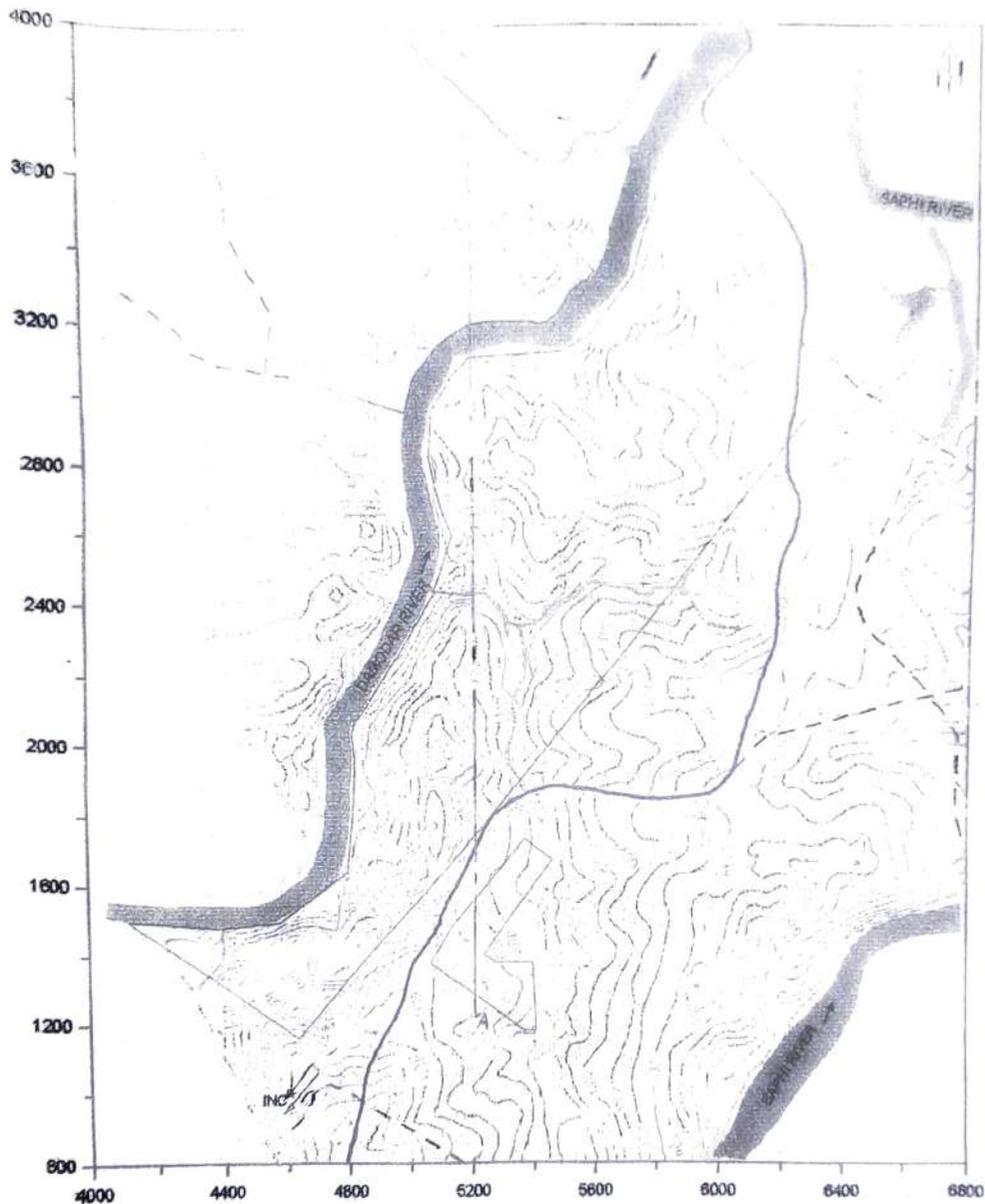
CMPDI

1	2	3	4	5
		mm	mm/m	mm/m
2.	Marginal impact on stability of stooks. The stooks with marginal factor of safety may collapse increasing loading on adjoining stooks.	-	<5	<5
3.	Failure of a few stooks may lead to chain of failures causing partial or total collapse of area. Thus causing additional subsidence on overlying horizons.	-	>5	>3
<u>OVERLYING WORKINGS</u> (Packed or stowed)				
1.	Practically no impact on stowed workings. Some loss of water.	-	-	<5
2.	Complete loss of water from stowed areas and also from adjoining rise side areas.	-	-	>5
<u>WATERLOGGED OVERLYING WORKINGS</u> (Standing on developed pillars)				
1.	Practically no impact on pillars, galleries and water retaining capacity of the workings.	-	-	<3
2.	Marginal loss of water through fine cracks in strata around. Dewatered areas may have risk of fires, roof falls, side spalling, floor lifting.	-	-	<5
3.	Major loss of water. High fire risk in dewatered areas with roof falls, side spalling, floor lifting, etc.	-	-	5-10
4.	Total loss of water. Very high fire risk with severe floor lifting, roof falls and spalling.	-	-	>10
<u>WATERLOGGED OVERLYING WORKINGS</u> (Standing on reduced pillars/stooks)				
1.	Stooks may collapse causing additional subsidence on surface.	-	-	<3
2.	Partial loss of water. Collapse of stooks. Additional surface subsidence. Fire risk.	-	-	3-5
3.	Total loss of water. Collapse of workings. Additional surface subsidence; fire risk.	-	-	>5

Subsidence Prediction of Churi-Benti Project				CMPDI
1	2	3	4	5
		mm	mm/m	mm/m
<u>IN CURRENT WORKINGS FROM SUBSIDENCE AT THE LEVEL OF SURFACE</u>				
1.	Practically no impact.	-	-	<5
2.	Leakage of air. Fire in goaves at shallow depth.	-	-	>5
<u>IN CURRENT WORKINGS FROM SUBSIDENCE AT THE LEVEL OF OVERLYING TATER BODIES</u>				
1.	Practically no impact	-	-	<3
2.	Marginal increase in make of water.	-	-	3-5
3.	Appreciable increase in make of water.	-	-	5-10
4.	Heavy increase in make of water, which may lead to inundation.	-	-	>10
<u>SURFACE ATMOSPHERE</u>				
1.	Practically no impact.	-	-	<5
2.	Some air from underground workings at shallow depth may leak to surface.	-	-	5-10
3.	Air leakage from shallow depth workings. If the workings have fire, surface atmosphere is likely to be polluted by gases coming from the fire.	-	-	>10
<u>SUB-SOIL</u>				
1.	Practically no impact.	-	-	<3
2.	Very little impact in the form of reduction of water retaining capacity.	-	-	3-5
3.	Temporary loss in water retaining capacity. Cracks filling may improve water retaining capacity.	-	-	5-10
4.	Long term loss of water retaining capacity. Suitable protective measures necessary.	-	-	>10
<u>AGRICULTURE</u>				
1.	Practically no impact.	-	-	<5
2.	Marginal impact, i.e. reduction in yield due to loss in water retaining capacity of sub-soil.	-	-	5-10
3.	Major impact, i.e. sizeable reduction in	-	-	>10

1	yield.	2	3	4	5
			mm	mm/m	mm/m
<u>FOREST AND PLANTATION</u>					
1.	Practically no impact.	-	<10	<5	
2.	Temporary loss in water retaining capacity of top-soil may affect undergrowth slightly. Slight tilting of plants/trees.	-	10-20	5-10	
3.	Short term impact on trees in zones having cracks. The cracks may get filled in due course. Tilting of trees.	-	20-50	10-20	
4.	Wide cracks may severely affect undergrowth but may not have much impact on large trees except those in the tensile strain zone where wide cracks develop; high tilting may cause some trees to fall in the high slope zone.	-	>50	>20	


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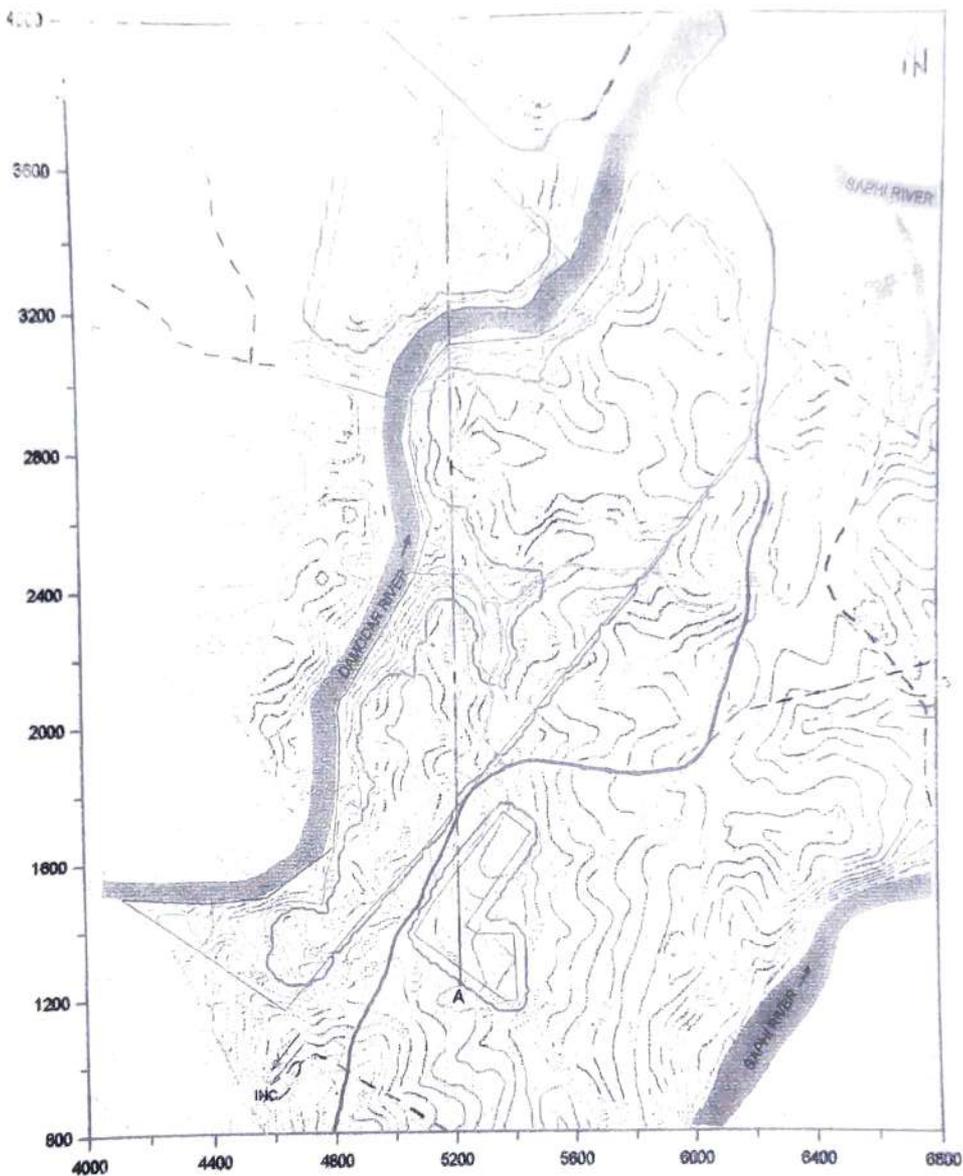
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- ORDINARY ROAD
- HT LINE
- HFL
- MINE BOUNDARY
- BUILT UP AREA
- AREA FOR CM DEPLOYMENT

NOTE: ALL DIMENSIONS ARE IN METER

CUSTOMER: CENTRAL COALFIELDS LIMITED		JOB NO: CHAMBI											
JOB TITLE: SUBSIDENCE PREDICTION OF CHUR BENTI UGP													
SUBJECT SURFACE TOPOGRAPHY BEFORE MINING	ACTIVITY	NAME	DRILL										
	PREPARED	V. KISHOR	S. NIGAM										
	PROCESSED	V. KISHOR	S. NIGAM										
	APPROVED	S. K. SETHI	S. NIGAM										
	APPROVED	S. K. SETHI	S. NIGAM										
<table border="1"> <thead> <tr> <th>REVISION</th> <th>DATE</th> <th>DESCRIPTION</th> <th>REV BY</th> <th>APP BY</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> </tr> </tbody> </table>		REVISION	DATE	DESCRIPTION	REV BY	APP BY						<p>CMPDI CENTRAL COALFIELDS LIMITED</p>	
REVISION	DATE	DESCRIPTION	REV BY	APP BY									

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Chur Benti UGP Project
N.K. Area



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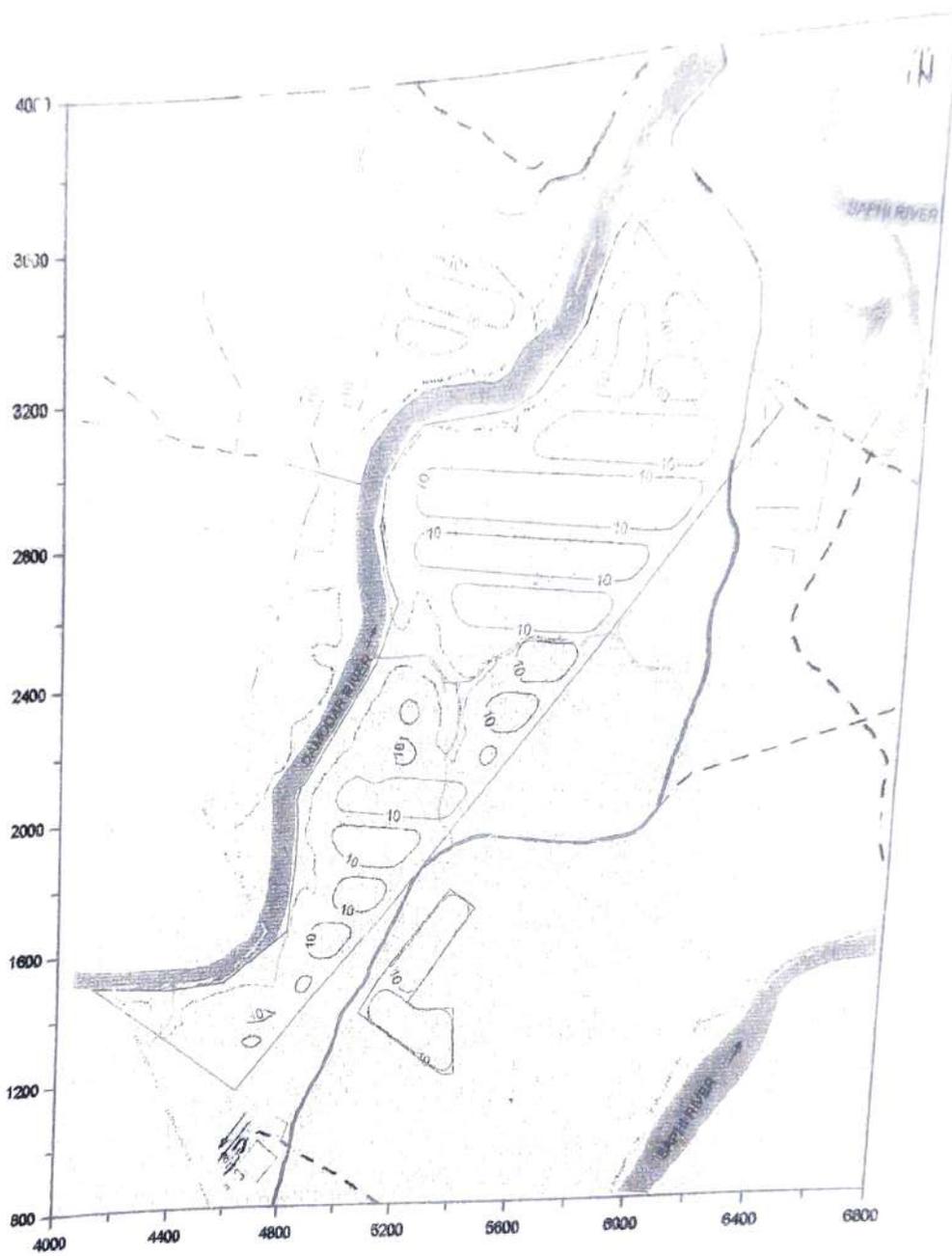
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- BUILT UP AREA
- AREA FOR CM DEPLOYMENT
- SUBSIDIENCE INFLUENCED AREA

NOTE: ALL DIMENSIONS ARE IN METER

CUSTOMER: CENTRAL COAL FIELDS LIMITED		JOB NO. 1000000	
JOB TITLE: SUBSIDIENCE PREDICTION OF CHURU BENTH VOP			
SUBJECT: SURFACE TOPOGRAPHY AFTER MINING OF CB PANELS	ACTIVITY	DATE	BY
	PREPARED	26/08/2010	SK
	PROCESSED	26/08/2010	SK
	CHECKED	26/08/2010	SK
APPROVED	26/08/2010	SK	
SCALE: 1:5000		DATE: 26/08/2010	
CMPDI		JOB NO. 1000000	
JOB NO. 1000000		JOB NO. 1000000	

REVISION	DATE	DESCRIPTION	REV. BY	APP. BY
HEUTEKOR				

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Churi Benth Vop Project
N.K. Arora - CCL



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 - AREA FOR CM DEPLOYMENT

AREA >10MM/MM STRAIN

NOTE: ALL DIMENSIONS ARE IN METERS

CUSTOMER: CENTRAL COALFIELDS LIMITED

PROJECT TITLE: SUBSIDIANCE PREDICTION OF CHURN BENTI LUMP

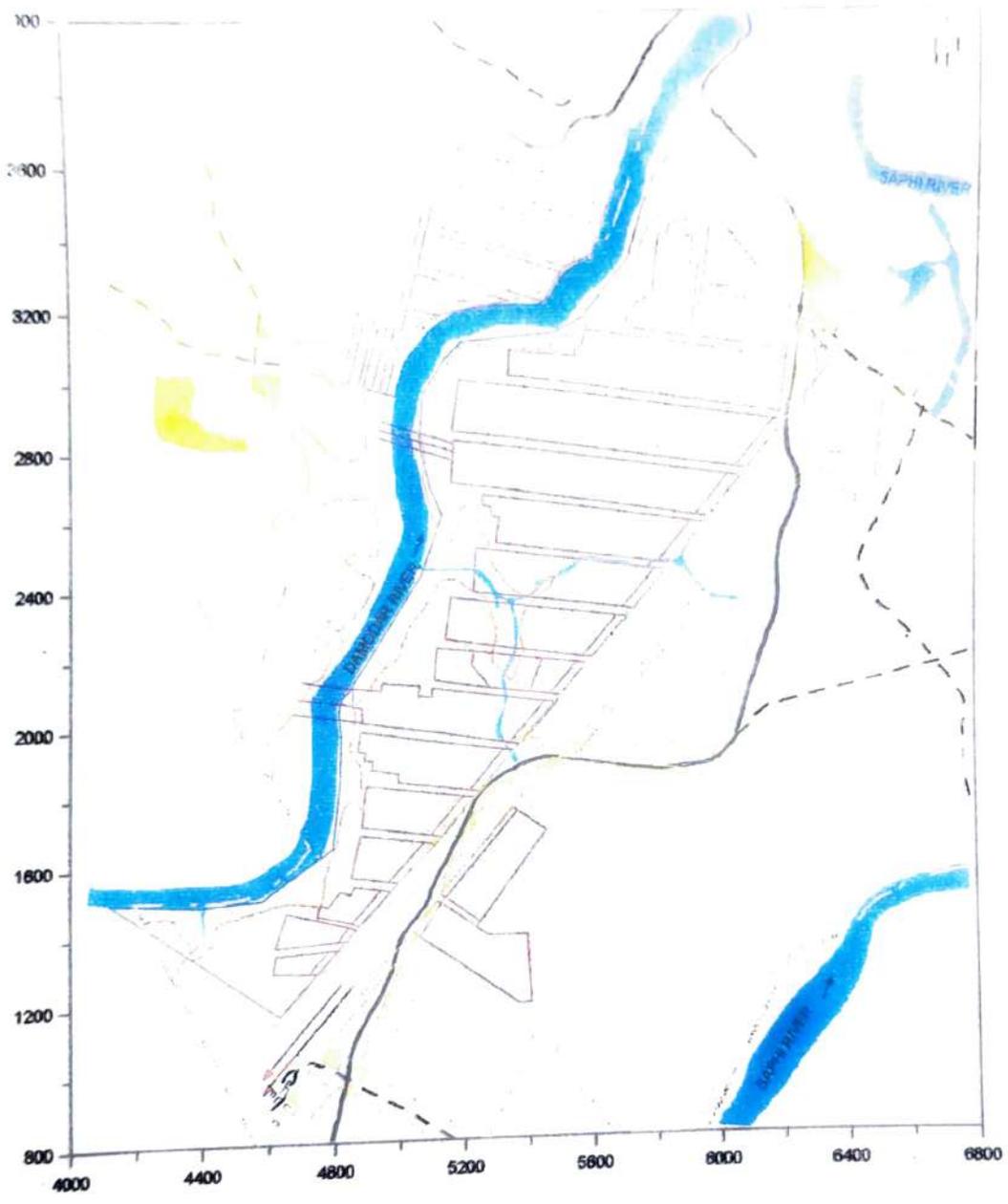
ACTIVITY	STATUS	DESIGN	DATE	BY	DATE
PREPARED	✓	✓	16-02
PROCESSED	✓	✓	16-02
APPROVED	✓	✓	16-02
ISSUED	✓	✓	16-02

SCALE: 1:1000

DATE: 16-02-2016

REVISION	DATE	DESCRIPTION	REV. BY	APP. BY

Aj
Project Officer
 Churn Benti UG Project
 N.S. 1000



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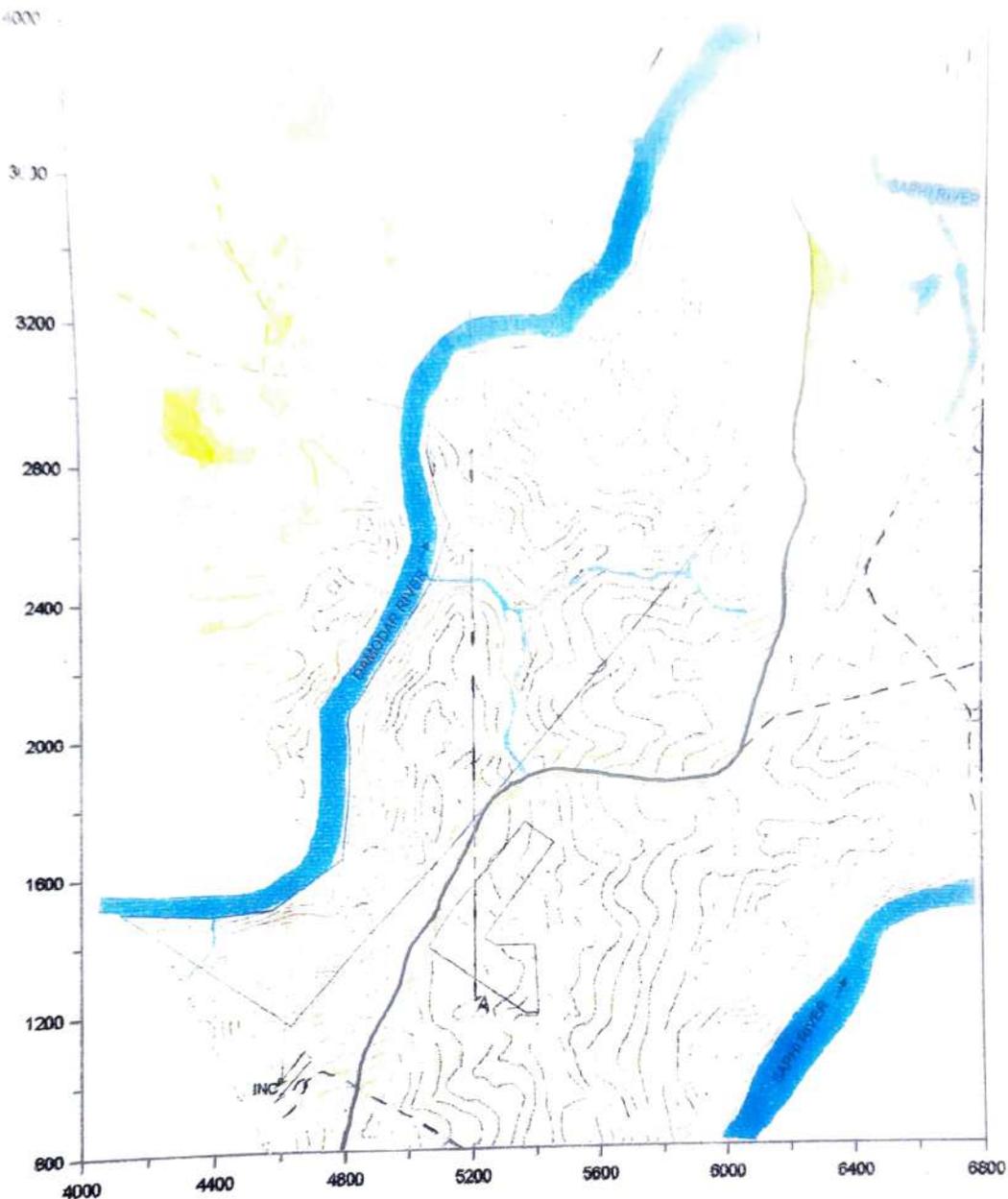
- AREA CONSIDERED FOR LHD
- PROPOSED PANELS FOR CM DEPLOYMENT

NOTE: ALL DIMENSIONS ARE IN METER

CUSTOMER		CENTRAL COALFIELDS LIMITED		JOB NO. 6903001	
JOB TITLE		SUBSIDENCE PREDICTION OF CHUNI BENTI UGP		JOB NO. 6903001	
NO.	ACTIVITY	NAME	DESIGN	ISSN	DATE
1	PROPOSED	V. SINGH	01.06		
2	PROCESSED	V. SINGH	01.06		
3	APPROVED	D. K. SINGH	01.04		
4	APPROVED	EX. OFFICERS	01.04		

REVISION	DATE	DESCRIPTION	REV. BY	APP. BY

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N.K. Area, CCL



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NOTE ALL DIMENSIONS ARE IN METER

CUSTOMER: CENTRAL COALFIELDS LIMITED		JOB NO. (S/N)MS01	
JOB TITLE: SUBSIDENCE PREDICTION OF CHUNBENTI UOP		DATE	
SUBJECT: SURFACE TOPOGRAPHY BEFORE MINING	ACTIVITY	NAME	DESG.
	PREPARED	V. SINGH	4-86
	CHECKED	V. SINGH	5-86
	APPROVED	D. K. SINGH	25-86

REVISION	DATE	DESCRIPTION	REV. BY	APP. BY
REVISION				



CMPDI
100 PER COMPANY

SCALE: 1:5000
(SEE NEXT PLATE)

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SUBSIDENCE PROFILE ALONG LINE AA'
(At the end of mining)



SURFACE PROFILE ALONG LINE AA'
(At the end of mining)



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SCALE: ALL DIMENSIONS ARE IN METRES

DESIGNED BY: CENTRAL CONSULTANTS LIMITED

PROJECT: TOTAL SUBSIDENCE PREDICTION OF COAL WORKINGS

NO.	REVISION AND SURFACE PROFILES ALONG LINE AA' AS SHOWN IN PLATE 3, FIG. 3	DATE	BY	CHKD.	DATE	BY
1	ISSUED					
2	REVISED					
3	REVISED					
4	REVISED					
5	REVISED					

REVISION	DATE	DESIGN FOR	REV. BY	APP. BY
		REVISION		

CMPCDI

REGISTERED OFFICE :

Gondwana Place, Kanke Road
Ranchi - 834 008
(Jharkhand)

REGIONAL INSTITUTES :

क्षेत्रीय संस्थान - I वेस्ट एंड, जी. टी. रोड आसनसोल - 713 301 (पश्चिम बंगाल)	Regional Institute - I West End, G. T. Road Asansol - 713 301 (West Bengal)
क्षेत्रीय संस्थान - II कोयला भवन, कोयला नगर धनबाद - 826 005 (झारखंड)	Regional Institute - II Koyla Bhawan, Koyla Nagar Dhanbad - 826 005 (Jharkhand)
क्षेत्रीय संस्थान - III गोंदवाना प्लेस, कान्के रोड राँची - 834 008 (झारखंड)	Regional Institute - III Gondwana Place, Kanke Road Ranchi - 834 008 (Jharkhand)
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क्षेत्रीय संस्थान - VI पोस्ट : सिंगरौली - 486 889 जिला : सिंधी (मध्य प्रदेश)	Regional Institute - VI P.O. : Singrauli - 486 889 Dist. : Sidhi (Madhya Pradesh)
क्षेत्रीय संस्थान - VII गृह निर्माण भवन सचिवालय मार्ग भुवनेश्वर - 751 001 (उड़ीसा)	Regional Institute - VII Grih Nirman Bhawan Sachivalaya Marg Bhubaneswar - 751 001 (Orissa)

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Churi Benti U.S. Project
N.K. Area, CCL

सेन्ट्रल माईन प्लानिंग एंड डिजाइन इन्स्टीच्यूट लिमिटेड

(कोल इंडिया की अनुषंगी कम्पनी)

CENTRAL MINE PLANNING & DESIGN INSTITUTE LIMITED

(A Subsidiary of Coal India Limited)

गोंदवाना प्लेस, कान्के रोड, राँची 834 008, भारत

फ़ोन : (+91 0651) 2230002, 2230483

फ़ैक्स : (+91 0651) 2231447

वेबसाइट : www.cmpdi.co.in



Gondwana Place, Kanke Road, Ranchi - 834 008, India

Phone : (+91-0651) 2230002, 2230483

Fax : (+91-0651) 2231447

Web Site : www.cmpdi.co.in