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Land Deformation Due to Underground Coal Mining - A Case Study

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Ground movement, a foregone conclusion of underground mining, will show up in the form of land deformation at the surface. Subsidence studies were conducted by mind tank, Central Institute of Mining and Fuel (Dhanbad), over and around the bord and pillar panel of Jharia Coalfield, Jharkhand to probe into the impacts on land environment. The extraction area has been correlated with the size of the planar and surface subsidence area. The affected area was larger than the extraction area. The change in surface topography will also affect the surface drainage pattern as dealt in this paper.

KEYWORD

Subsidence, Coalfield, Mining, Seam.

INTRODUCTION

Subsidence is an inevitable consequence of underground mining - it may be small and localized or extended over large areas, it may be immediate or delayed for many years (Singh, 1992). There are various historical evidences of subsidence (Agriola, 1950; Gregory, 1982; Kratzsch, 1983; Whittaker and Reddish, 1989) which has caused negative impacts on land surface. Ground movement study was carried out over 10/S panel of 11 seam at Jamadoba 6 and 7 pit of Jharia Coalfield in the course of mining and even after mining to determine the ultimate subsidence basin.

Geology

The sickle shaped Jharia Coalfield is situated about 260 km north-west of Calcutta in Dhanbad district (Jharkhand) within the heart of Damodar Valley. The total area of this coalfield (about 38 km long and 19 km wide) is about 456 km^2 (Banerjee, 1998; Chandra *et al.*, 2000). The basement metamorphic rocks are overlain by the Talchir formation followed by the Barakar formation which is the main coal bearing zone. Above it comes the Barren measures followed by the Raniganj formation which is also coal bearing (Chandra, 1992). Based on structural configuration, 2 synclines separated by an anticlinal flexture are observed (Mathur, 1993). Originally T.H. ward identified 18 seams in the Jharia Coalfields and numbered them from I to XVIII (Fox, 1930).

Geo-mining details

10/S panel of 11 seam was extracted by bord and pillar method of mining in conjunction with hydraulic sand stowing. The seam has a thickness of 7.31m; hence coal was extracted in two sections, each having the height of extraction of 2.70 m. The panel lies within a depth of 360 and 402 m, the gradient being 1 in 7.2. The overlying strata consist of 53.24% sandstone. There are three seams (14, 16A and 16) lying above the panel, working conditions of each overlying seam is given in table 1. The percentage of coal extraction is 65.

MATERIAL METHOD

Subsidence measurement

The instrument used for the vertical measurement was auto level having a least count of 0.1 mm. The horizontal displacements have been measured with steel band by providing a constant tension of 5 kg with the help of spring balance in order to prevent

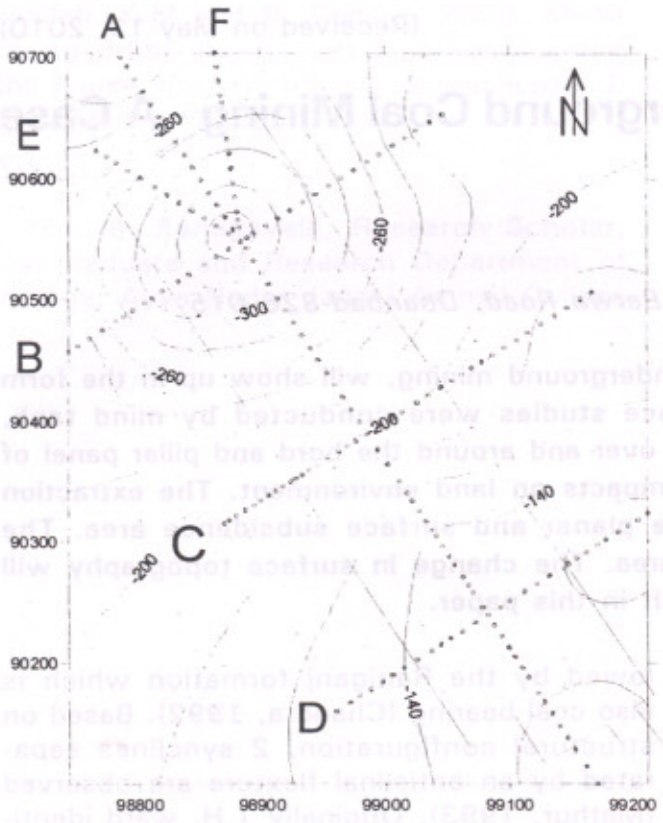

Figure 1. *Subsidence contour over 10S panel with monitoring stations*

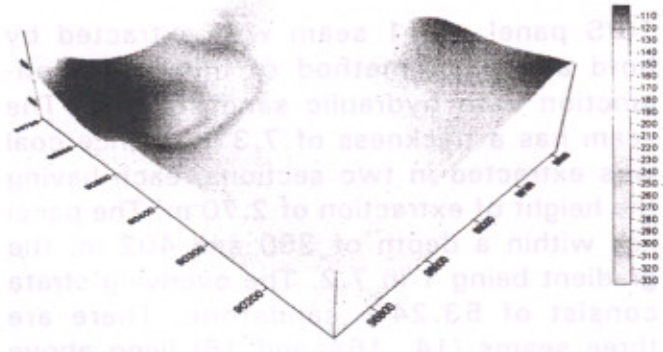

Figure 2. *Three dimensional view of the subsidence*

the sagging of the tape. The average distance between the monitoring stations are 10 m. The monitoring stations have been elevated above ground surface to prevent from the hindrance of measurement from the bushes. The least count of the steel band is 1 mm.

Layout of monitoring stations

The mining area has different surface fea-

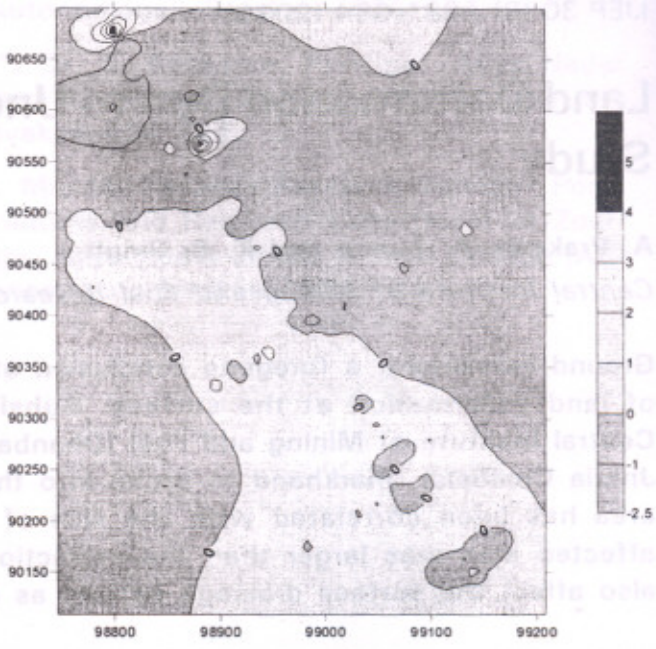

Figure 3. *Horizontal strain formed at the ground surface due to mining*

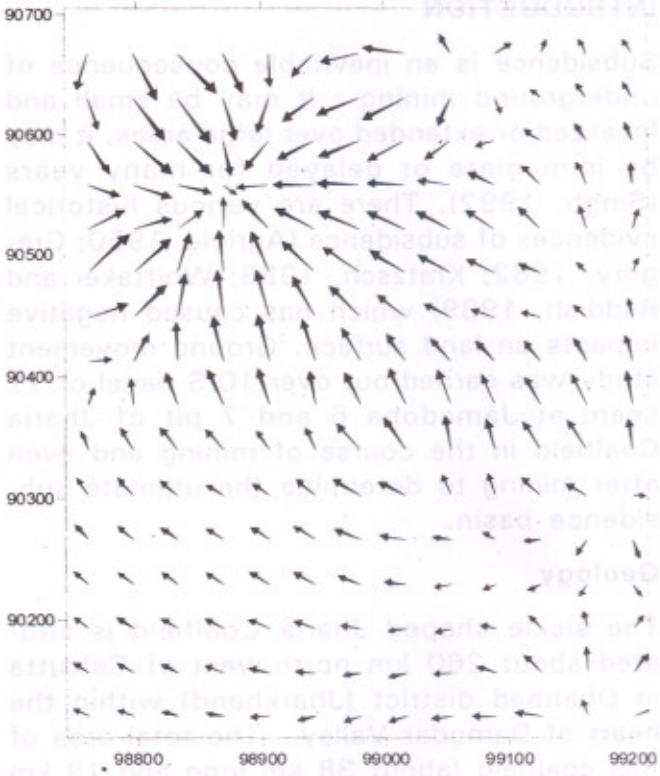

Figure 4. *Anticipated surface drainage pattern due to subsidence*

tures, like nallah, plantation and barren land. There are 186 monitoring stations above and around the 10S panel of 6 and 7 pit of

Table 1. *Working conditions of overlying coal seams at Jamadoba 6 and 7 pit*

Seam	Working condition	Depth, m
14	Partly stowed and mostly standing on pillars	402
16A	Partly standing on pillars and mostly caved goaf	270
16	Partly standing on pillars and mostly caved goaf	249

Table 2. *Result of subsidence investigations over 10S panel*

Parameter	Outcomes
Maximum subsidence	427 mm
Subsidence with respect to height of extraction	7.9%
Maximum slope of subsidence	11 mm/m
Maximum compressive strain	2.5 mm/m
Maximum tensile strain	6.23 mm/m
Width/depth	0.38
Mining area	85550 m^2
Planar area affected	283976 m^2
Surface area affected	315811 m^2
Volume of coal extracted	290560 m^3
Volume of subsidence	64150 m^3

Jamadoba Colliery, Jharia, in six different lines, namely A, B, C, D, E and F shown in figure 1. The stations have been anchored beyond the edge of the panel on all the sides wherever practically possible to study the area of influence due to working.

RESULT AND DISCUSSION

Influence of subsidence on land

The measurement was carried out over 10S panel since May 2004 till March, 2007. The panel was completed one year back. It was not possible to compute non-effective width of extraction owing to the presence of old goaves over and around the working panel. Maximum subsidence was measured upto 427 mm (Anon, 2007); the contour diagram of the same is shown in figure 1. Maximum subsidence in Indian geo-mining condition for coal extraction with hydraulic sand stowing ranges between 5-10% of height of coal extraction (Lokhande *et al.*, 2005). Three dimensional view of the subsidence is shown in figure 2.

As the mining was done with stowing the development of the horizontal strain was less. Most of the region is having the strain values much within the permissible limit (Figure 3). The area having red colour indicates strain values above permissible limit, which is negligible. Most of the area is under compressive strain (green colour).The planar area and surface area deformed with respect to mining area is 3.3 and 3.69 times, respectively. The volume of subsidence is 22% with respect to volume of coal extracted. There is possibility of logging of water at surface at maximum subsidence region. Surface subsidence will alter the topography of the affected area and, inturn, surface drainage pattern. The anticipated post subsidence surface drainage due to the ground movement at the surface is shown in figure 4. The top soil will tend to move, along with the surface run off or rain, towards the zone of maximum surface as shown by the arrow diagram. Since the intensity of the surface deformation is not much, it may not affect the soil characteristics of the area. The outcome of the subsidence investigations is given in table 2.

CONCLUSION

The planar area influenced at the surface due to underground mining was 3.3 times the mining area. The amount of vertical movement (7.9%) was within the expected range (5-10%). The compressive and tensile strain values were within the safe limit. Coal was extracted without causing any remarkable damage to the surface structures. Hence, underground coal mining with proper hydraulic sand stowing is one of the paramount techniques to provide safety to the surface features.

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