GEOTECHNICAL MAPPING AS A TOOL IN THE ASSESSMENT OF STRATA CONTROL PROBLEMS IN PK-2 UNDERGROUND COAL MINE A CASE STUDY

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Abstract

In Singareni Collieries Company Limited, the PK-2 Incline is situated in the northeastern extremity of Manuguru coalbelt. In this block, two seams are under exploitation. In seam No.-I, as dip side working districts are approaching a depth of 300m from the surface, it is reported that the thickness of coal bearing roof strata varies from 1 to 2m followed by highly disturbed stone roof with multiple cleavage planes and coal streaks besides unconsolidated layers as observed at some places. As a pre requisite and to ascertain the reasons for the unstable roof rock conditions so as to establish a system, a detailed underground geotechnical mapping was taken up by conducting different studies viz. Lithological characteristics of roof strata, Physico-mechanical properties, geographic features of the study area, recording the joints and trend of roof falls in underground workings and Rock Mass Rating (RMR). Based on these studies, it is found that "Crevasse splay", "Kink zone", are potential hazardous zones, structural features are also found to be equally responsible, geographic features like streams are found to be causative factors of unstable roof conditions ,strength of roof strata is poor and as per RMR, roof strata is categorized under "POOR" class.

Introduction

Northeast boundary (along the river bank) of PK-2 Incline forms the limit of the Manuguru coalbelt in the northeast and thus this block forms an integral part of this area . The block is roughly in parallelogram shape. The block covers an area of about 3.6 sq.km and is enclosed between North latitudes 17^0 58' 20": 17^0 59 30" and east longitudes 80^0 48' 25": 80^0 50' 25".

Seam no.-I is the bottom most workable seam with a varying thickness of 1.50m to 4.50m. The seam is extensively developed and partly depillared with sand stowing on the south side of the block. The workings have crossed the 250m depth line. Average width of Gallery in 14 dip district is 2.80m and the height is 2.40m. Size of coal pillar is 38m x 38 m. The corresponding figures for 6 dip development district are 2.90m, 2.20m and 35m x 35 m respectively.

Overlying the seam no. I, with a parting variation of 3 m to 8 m, seam no. II is also extensively developed. Thickness of seam II varies from 2.0m to 3.0m. Above seam II with a parting variation of 0.50 to 12.0 m., overlying seam no. III is virgin. Further, 1m to 5m thick virgin seam IV occurs above seam no. I & III with a parting of 3 to 5 m.

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Geology and Structure

The PK-2 mine block is situated in the north eastern extremity of the Manuguru coalbelt. The trend of coal bearing strata is northeast - south west and with dip of NWLy dips of around 8 to 12^0 (Fig.1). The block is structurally less disturbed, since only four faults (mainly dip faults of normal gravity type) are observed to effect the seams.

In the Manuguru coalbelt, the most persistent coal seam proved is the "Thick seam", This seam exhibits splitting and coalescing phenomenon as it is seen to split into three sections around PK-2 mine block which are designated as section-II, Section-III and section-IV in ascending order. In this mine area, the bottom two seams namely section-I and section-II are under exploitation. While the section-III and Section -IV are yet to be mined.

It may be mentioned here that section-II, III and IV are part of thick seam and these seams are designated locally by mining authorities as seam-II, III and IV respectively. For the purpose of convenience, the nomenclature as adopted by mining authorities is only followed.

In the dip side of PK-2 mine block, fault F5 is interpreted based on the available boreholes data. Considering the spot levels of underground workings of seam-II, the floor contours are drawn and found that position of fault F5 is shifted further dip side (Fig. -1). Keeping in view, the location of fault F5 with reference to 14 dip district workings, the unstable roof conditions might have prevailed.

Detailed Underground Geotechnical Mapping

A detailed underground geo technical mapping has been carried out in the seam-I to pick up the trends of joints, sedimentary features, locating roof falls and their causative factors etc. It is noticed that within the study area, some times the workings are in top section with sandstone as immediate roof and elsewhere the workings are in middle section where part of the seam forms the immediate roof. It is found that in both cases the unstable roof conditions are prevailing. Thickness of the seam is drastically reducing in the dip side of 14-dip district. Conversely on the rise side, roof is stable (Fig.-2). Unstable roof conditions are observed only beyond 33L.workings.

While reducing the width of galleries, slight improvement in the roof stability is achieved. An attempt has been made to stagger the 34LS and 33LS in 14D to improve the roof conditions.

Study of Lithological Characters of Roof Strata

Weak Bonding between thinly laminated sandstone strata, intercalated with shale : Usually roof of working section is intercalated with shale bands very often, some beds separate readily along mica rich bedding planes into flaggy slabs. In some places micaceous laminae permit the roof to separate in layers and to break in large slabs. The shale is susceptible to moisture slaking and over a long period of time, large falls develop.

Moebs and Ellenberger (1982) coined term : "Crevasse splay", in a non genetic descriptive sense, designates a lithologic unit consisting of sandstone thinly interbedded with shale or thin bedded,

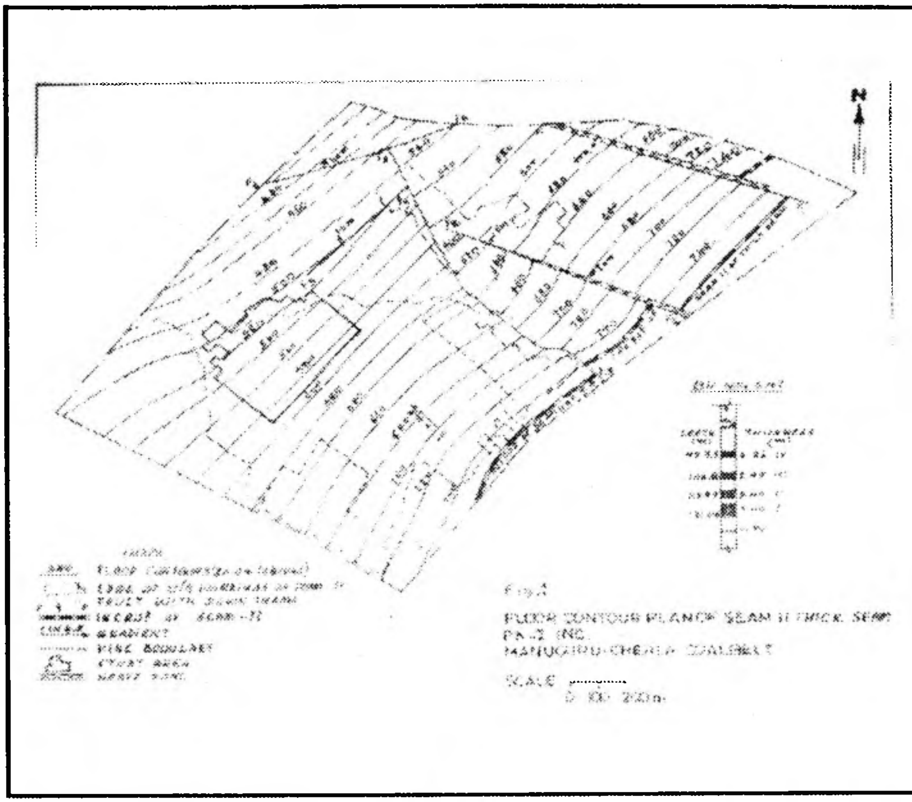

Fig.1

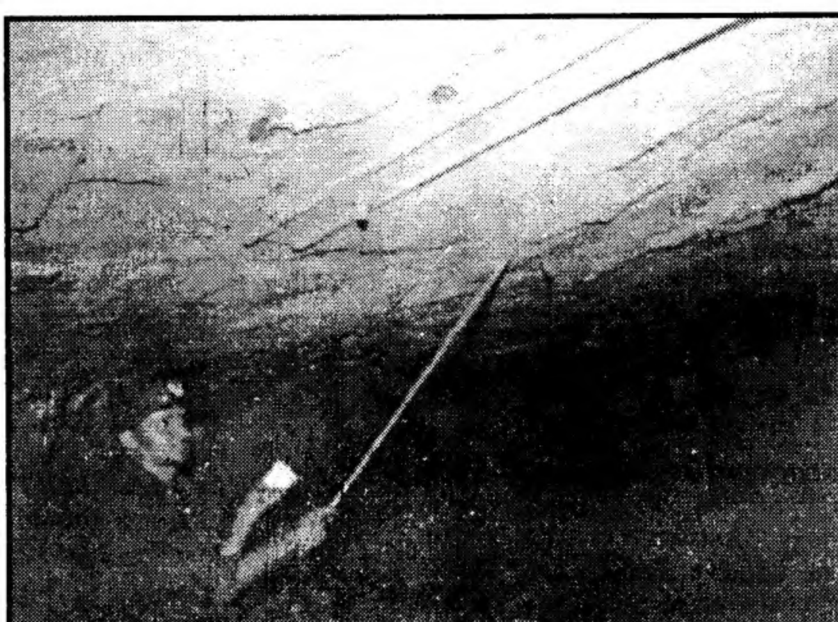

Fig.2

laminated, micaceous sandstone. The inherent weakness of splay type of deposit is due to the lack of bonding between the mica or shale rich laminations. Roof falls in splay sequences generally occur when a separation along a bedding plane occurs (Fig. 3)

"Kink zone" : From the exposed roof strata of working section, when-ever coal is left, failures of roof is observed on one side of the gallery (Fig. 4) Krausse et al. (1979) used the term "Kink Zone" for narrow zones of compressional cracking and sagging which develop in the immediate roof after mining. "Kink zones" most commonly develop on one side of the gallery or near the center line. Lateral stresses buckles the roof layers downward and jams their ends together. Some lithologies are more susceptible than others in development of Kink zones. It is observed that the "Kink zones" are not following any particular direction. It is found both in level galleries and dip galleries Kink Zones resulting into failure of roof. Hence, the support provided is becoming ineffective (Fig-5).

Whenever, shaly sandstone forms the roof of working section, mostly it comprises of incompetent *"flaggy sandstone"* and" *trashy sandstone* " leading to the failure of roof (Noel N. Moebs, 1977). As the lithology is not persistent, at some places, pebbly silt stone with pyrite forms the roof of working section and in such conditions roof is stable .

Joints

Joints are fractures along which the two blocks on both sides of the fractures have not experienced relative movement; joint may cut the bedding planes of the strata vertically or obliquely. Not all joints will affect roof stability but closely spaced joints commonly contribute to bad roof.

About 48 joints are mapped and their rose diagram is shown in Fig.-6 which indicates that most prominent joints are trending in N-S direction and next prominent joints are in E-W direction. The least prominent joints are in the direction of N 60^0 W. All these joints are sub vertical to vertical tight joints and with a spacing of 0.50 m. to 2.0 m. The trend of the level galleries is in N 50^0 E and dip galleries are in N 40^0 W (Fig-6).

Topographic Features

A stream / channel is generally created by surface run off water that cuts through a weak rock zone or an area of high fracture density. Streams tend to follow surface fractures. It is generally known that in the coal mines area, the roof rocks immediately under and adjacent to a stream are almost always less stable much liable to fall once under active mining. Over the study area, one such stream is passing through the block and contributing for the unstable roof conditions.

Physico Mechanical Properties

To assess the strength of the roof strata of seam I, different physico-mechanical properties viz Density, Compressive strength, Tensile strength,, Shear strength, Youngs modulus, Impact strength Index and Protodyaknow Index are considered. BH No. 547 which is located on the rise side of study area and is about 400 m away from 6 dip district in SE direction is having data on physico mechanical properties A perusal of this data along with strength data from RMR samples indicate that roof of seam-I is stable with a range of compressive strength of 155 to 425 kg/ cm^2. However in practical, the roof fails in the study area.

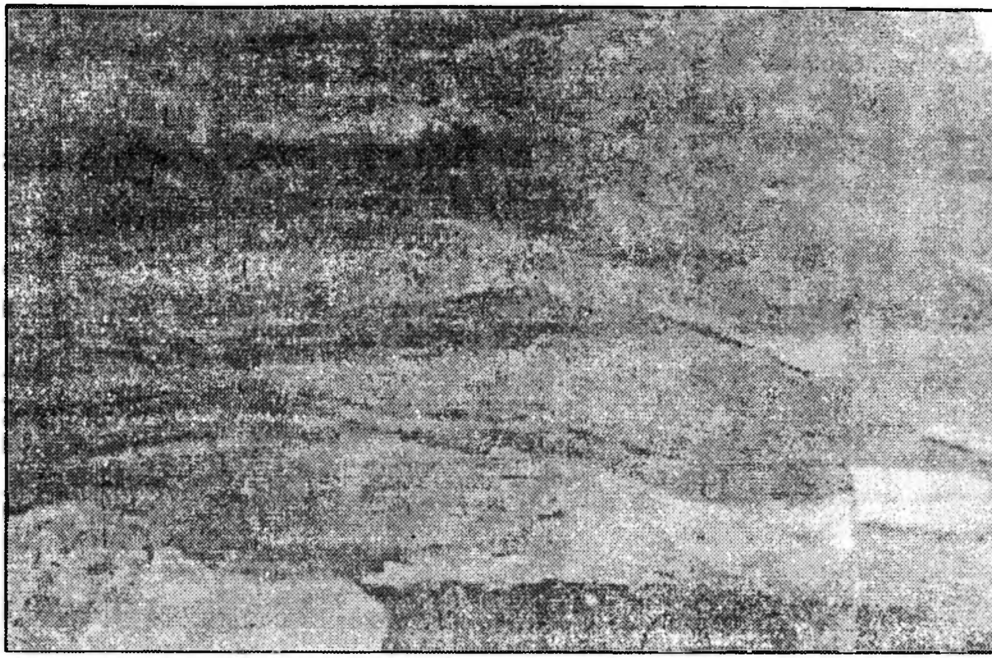

Figure. 3 "Crevasse Splay" in the Roof of working Section.
Location 5D/23L.

Figure. 4

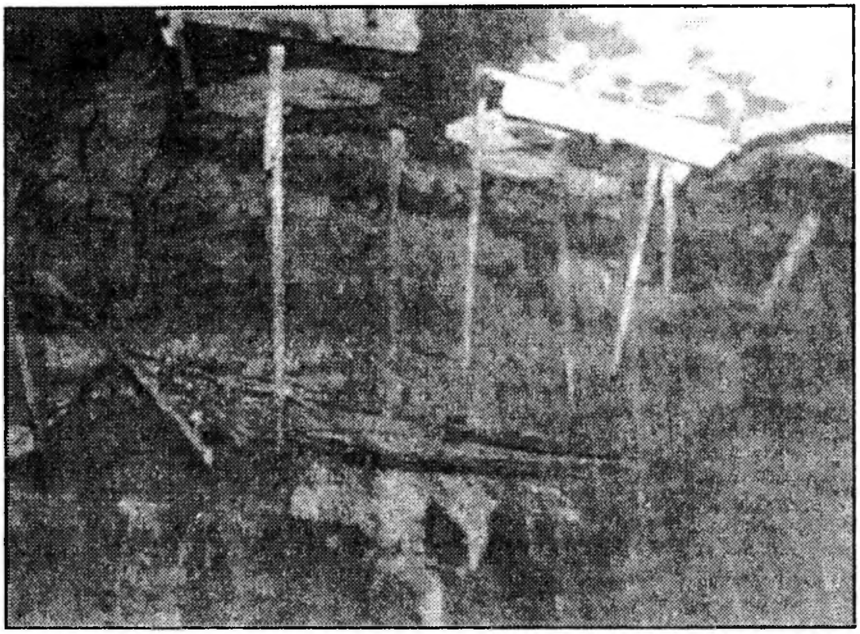

Fig. 5 - "Kink Zone", the causative factor of failure of coal roof and resulting the roof bolts as ineffective.
Location-28LN/6D.

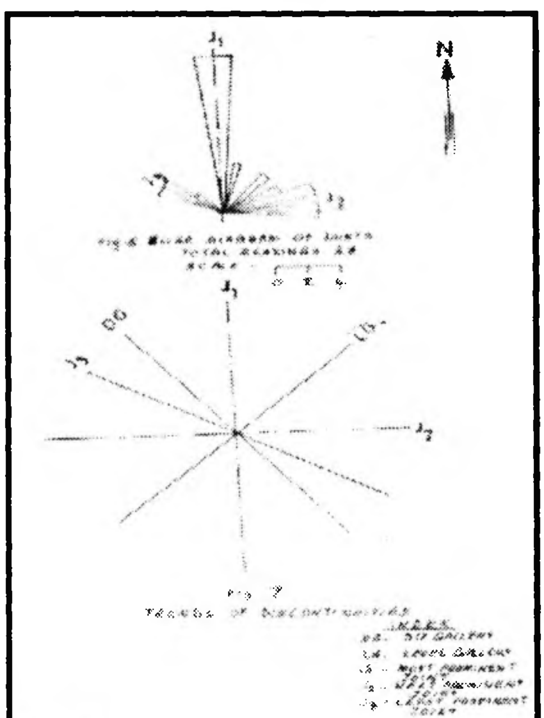

Fig. 6

Rock Mass Rating (RMR)

The Rock Mass Rating is useful to identify the most significant parameters influencing the behavior of a rock mass and divide a particular rock mass information into a number of rock mass classes of varying quality. From these studies, roof support guide lines are provided.

RMR studies in 6 Dip district and 14 dip district are taken up individually. Geotechnical mapping was carried out in the study area and the data pertaining to layer thickness, ground water seepage rate and geological structural features were generated. Density, strength and slake durability of the roof strata were determined in the Laboratory by conducting tests on lump samples collected from two locations in each district.

In the 14 dip district the roof is exposed to a thickness of 2 m. at 34LN/10D and 34 LS/14R. Similarly in 6 dip district, the roof is exposed to a thickness of 2 m at IR/29LN and 9R/30LS. The details of RMR of these locations are furnished hereunder.

Rock Mass classification software (version v.2.0) developed by CMRI, Nagpur, was purchased and is used to arrive at RMR, carried out in four locations in the study area. Using the software, the final RMR, Rock load and support Design are obtained.

As shown below, the summary of RMR of four locations indicates that roof strata is Classified under "Poor" Category.

Sl No.	Location	Weighted RMR	Class	Rock load t/m^2
14 Dip District				
1	34LN /10D	37	IV - " POOR "	5 - 7
2	34LS / 14R	36	IV - " POOR "	5 - 7
6 Dip District				
1	IR / 29LN	38	IV - " POOR "	5 - 7
2	9R / 30- LS	36	IV - " POOR "	5 - 7

Summary and Conclusions

The studies conducted in the 6 Dip and 14 Dip districts of I Seam are summarized and the following conclusions are drawn :

1. The workings have crossed 250 m. depth line and approaching the fault F5 in the dip side property. It is believed that because of this fault, the roof conditions have deteorated. Otherwise roof is stable in the rise side of the study area.
2. Based on the underground, geo-technical mapping, the causative factors of unstable roof conditions are found to be
   - "Crevasse Splay" of roof.
   - "Kink zone" / Roof Guttering" of Galleries
   - "Flaggy" and "Trashy sandstone" with intercalated shale in the roof strata

3. A seasonal nallah passing on the surface, through the study area contributes for bad roof conditions. Also it indicates the trend of fault F5 or the alignment of nallah itself may be along the fault plane.
4. From the strength point of view, the roof is strong.
5. However, the 2m roof strata of working section as per RMR is classified under "POOR" category with weighted RMR varying from 36 to 38 and Rock load ranges from 5 to 7 t/m^2, (based on the CMRI_ROCK software).

Recommendations

Based on the above findings, the following recommendations are suggested:

1. It is anticipated that roof conditions may not improve, since the workings are approaching fault F5 along Nallah, which is located at about 160 m. from the present workings. Hence, to ascertain the exact location, trend and throw of fault F5 and nature of strata, a total of five boreholes are required to be taken up. Once the fault direction / location is fixed, and strata conditions are favorable, then the workings can be extended further dip side.
2. In view of the present strata conditions, it may be desirable to take up the depillaring operations immediately after development.
3. Based on the CMRI_ROCK software RMR, Rock load values and roof support plan has been prepared.
4. The small pockets of property in seam I can be developed whenever the roof strata is favourable through overlying seam II by making tunnel.

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