

Experiential Method for Scheming of Support System in Mechanized Coal Pillar Mining

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Abstract: Mechanized room-and-pillar system of coal pillar mining using side dump loading machine or load haul dumper machine, or by continuous miner, is the presently most dominant underground method of extraction in India. Under this method of extraction, strata control is a major problem affecting safety and productivity of the mine. As per existing Director General of Mine Safety guidelines, systematic support rules must be followed at the depillaring faces irrespective of immediate roof rock type and competency. Therefore, there is a high chance that sometimes these systematic support rules give unnecessarily high support, or sometimes inadequate support, which may lead to roof failure at the face. As a result, there is a big loss of life and material including coal in terms of left-out ribs/stooks and other associated mining equipment deployed at the faces. Therefore, in the present paper, authors attempted to develop generalized empirical equations for estimating the required support load density at different places of the face based on geotechnical parameters of the mine and physico-mechanical properties of the immediate roof rocks for designing of support system during mechanized coal pillar mining.

Keywords: room-and-pillar, coal pillar, dump loading machine, extraction, depillaring faces

Introduction

Over the years, compiled statistics of accidents in Indian coal mines identified one of the major causes of mine accident as “fall of roof or sides” [1]. It is important to note that as many as 61.1% of the accidents are due to roof fall, accounting for 28.5% of total fatalities. Based on the statistical data of the accidents occurred in different underground Indian coal mines, it is found that a large number of accidents (about 45%) are taking place in freshly exposed roof areas. The thickness of the fall is generally less than 1 m in 80% of the cases. Falls occurred in all types of roof, with a higher incident rate in coal/shale rocks. Geological disturbances were reported to be the main cause in sandstone roofs. Wherever the falls took place, either no supports were provided or supports provided were inadequate or installed improperly. It was therefore felt that a comprehensive guide line needed to be developed for depillaring considering split and slice width, rock characterization, depth of cover and in situ stresses. To fulfill this objective, investigations were carried out based on field data collected from 30 coal mines. Out of these, 18 were chosen for numerical modelling spread over the major coalfields in the country. Based on modelling results, data were prepared for regression analysis to give separate equations for the estimation of rock load height RLH and required support load density *SLD* in the slice, junction, split and goaf edge. Field instrumentation was done in three mines to compare the results [2].

Section snippets

Appraisal of past work

Support guidelines for the development workings and junctions are carried out by different rock mass classifications such as the rock mass rating (*RMR*). The purpose of rock mass classifications is to quantify the existing weakness planes in a rock by assigning an index that also must include due weightage for rock strength, action of water, if present, weathering and different geological weaknesses. Of the many rock classifications starting with Terzaghi [3], the later by Bieniawski [4], [5]

Causative factors for developing load on faces

Field investigations and laboratory testing, along with a three-dimensional numerical model study for 18 underground coal mine running panels, was done to compile the findings in this paper. A total of 612 three-dimensional numerical

models were run with different combinations of geotechnical parameters obtained from field investigations and laboratory testing [2]. It was found that the following are the most common causative factors associated with support load at depillaring faces.

RMR and

Numerical modelling procedure

The geominig parameters used in the modelling include geometry of the area to be studied, rock properties (elastic modulus, strength, *RMR*, etc.) for each stratum, in situ stress field, etc. Further, necessary boundary conditions need to be applied. Finite difference method (FLAC 3D) solves the problem iteratively and one needs to make sure the convergence of the solution before analysing the results. The results provided by the solution are to be post-processed to assess the stability of the

Model study

The underground room-and-pillar mining problem is better represented as three dimensional. Since the line of extraction in the room-and-pillar mining is generally diagonal, complete panel of each individual mine has to be modelled to estimate the likely failure height of immediate roof strata in the split gallery, slice, slice junction and the goaf edges at the face during depillaring. From the underground mining experiences it has been seen that maximum load on the face reaches mainly when the

Development of equations for estimation of rock load height (RLH)

Before development of the equations for estimating the required support load density at the slice junction, within the slice, in the split gallery and at the goaf edge, it became necessary to study the effect of each factor for estimating the rock load height (RLH) while keeping the others constant. Therefore, for judging the qualitative nature of the curve, GDK-5A incline model results (arbitrarily) was chosen to see the effect of any influencing factor over the required rock load height

Field instrumentation and monitoring

To supplement the modelling results, vibrating wire stress meter and strain gauged rock bolts were used. Stress meter monitors the change in stress developed on the rib against slice during depillaring, while strain gauged rock bolt monitors the load exerted on to the support system either in the developed gallery or split level during extraction of a neighboring pillar and adjacent slice. Both types of the instruments gave readings till they went into the goaf. For this purpose, four mines

Procedure for estimation of different variables needed for developed equations

After going through the developed Eqs. (20), (21), (22), (23), it is clear that five variables are to be known to estimate the required support load density at different places of the face during depillaring operation. These variables are the depth of cover H , in situ stress ratio K , rock mass ratings of the immediate roof rock R , split and slice width W and rock density γ . Estimation procedure for K , R and γ are described below except for H and W which are directly obtainable.

Measurement is

Support design guidelines in depillaring faces

Once we know the required support load density in the split gallery, at the slice junction, within the slice and goaf edge of the depillaring face, the selection of proper support systems as per requirement (SDL, LHD or CM or conventional) and support pattern for respective areas can be designed. Based on past experiences on roof supports and their effectiveness along with pull test of different types of the bolts used in different underground mines, the load bearing capacities of different

Shyamsundarpur colliery, ECL

Jambad bottom seam (RVII) of 4.2 m average thickness at Shyamsunderpur colliery of ECL was developed in a single lift along the floor by conventional drilling and blasting methods 10–15 years back. Panel no. 24 of the above colliery was extracted by using SDL up to the height of 3.6 m leaving coal of 0.6 m along the roof. During field investigation it was found that the immediate roof of the seam is shaley sandstone and moderately cavable. The details of the geometrical parameters of the seam and

Conclusions

The proposed equations for the estimation of required support load density at the slice junction, within the slice, in the split gallery and goaf edge are developed and given in Section 6.2. Sometimes required support load density at the goaf edge comes to be less than the slice junction value from the developed equations, in such cases, slice junction value should be taken for the goaf edge also.

After knowing the required support load density (*SLD*) at different places of the depillaring face,

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