CHAPTER 1

INTRODUCTION

1.1 Introduction

Coal serves as the primary fossil fuel to fulfil energy needs through the thermal power plants in our country. Post-nationalization, the mechanisation of coal mines has made coal mining predominantly a surface mining activity. Compared to underground, opencast mines have contributed a more significant proportion of the total coal production for decades. Currently, our total coal production is 716 million tonnes, of which about 96% is contributed from the opencast and 4% from the underground (Ministry of Coal, 2021).

The mechanised opencast mines provide a scale of production that infuses sustainable profitability in operation. The layouts for these mines are planned to divide the mine-lease into the dumping area and the open pits. With the increase in production, these mines are increasingly requiring vast land. Further, with progressively increasing mining depth, the overall stripping ratio also increases, requiring a larger volume of waste rocks to be excavated and dumped safely. The mine leasehold rapidly gets insufficient for meeting the requirements of coal extraction and safer dumping of overburden. Hence, exploitation of the underlying coal reserves becomes essential for obtaining the coal production targets. In such situations, the coal production from the opencast mines creates massive heaps or the neo-hills of the internally dumped overburden over shallow cover depth.

Exploiting a deep coal resource through surface mining is highly challenging due to the unfavourably higher break-even stripping ratio. Due to space restrictions, internal dumping is mostly preferred over external disposal. Under such conditions, rehandling the previously backfilled overburden dump becomes necessary if an underlying coal seam is to be worked at a subsequent stage in the previously worked open pit. The underground mining of coal has to be resorted for the continuation of the requisite production in such conditions.

The Bord and Pillar method is widely adopted for underground extraction of coal in the Indian geo-mining conditions. It requires comparatively lesser capital investment and offers a flexible mining system and employment opportunity to a larger workforce without the requirement of a high level of skill. As per the study made by Singh and Dubey (1993), about 3 billion tonnes of coal are locked in the developed pillars without a techno-economically effective method of depillaring due to a large number of site-specific constraints. The diagonal line of the pillar extraction offers an excellent balance between the caving of strata in the goaf and the stability of the roof in slices. Straight-line extraction of pillars is mainly preferred to facilitate mechanised extraction of pillars at a faster pace. Assessment of the strata mechanics and its associated ground control challenges remain the primary concern for a safer depillaring operation in the underground working. The stability of the roof is required to be maintained at the working face along with the controlled and regular caving in the goaf till complete extraction in a panel. The majority of the depillaring workings operated in the Indian mines have competent overburden strata. The loading behaviour of such strata is entirely different from the condition where the majority of the overburden is formed of softcover. The placement of a soft overburden dump over the hardcover creates a dead loading condition. It also reduces the overall stiffness of the composite overburden, causing a completely different loading condition in the depillaring working. As the understanding of strata mechanics in depillaring working is limited to the intact state of overburden, the prevailing knowledge base requires fortification for a safer design of underground workings under softcover.

In the conventional strata condition, the overlying strata are classified as caving, fractured and continuous deformation zones. The immediate roof and the main roof form the caving zone, while the intact overburden forms the fractured and the continuous deformation zones. In this study, we define softcover as the overburden (OB) dump placed over the intact overburden of an underground mine (Figure 1.1). Thus, for the underground working considered in this work, the overlying strata comprise the parting strata that lie above the caved zone and the softcover on the top of the intact overburden. Thus, the overburden contains a combination of hardcover and softcover in this condition. The hardcover combines the thickness of strata representing the caving zone and the parting strata, while the height of the overburden dump/soil/unconsolidated strata represents the softcover thickness.

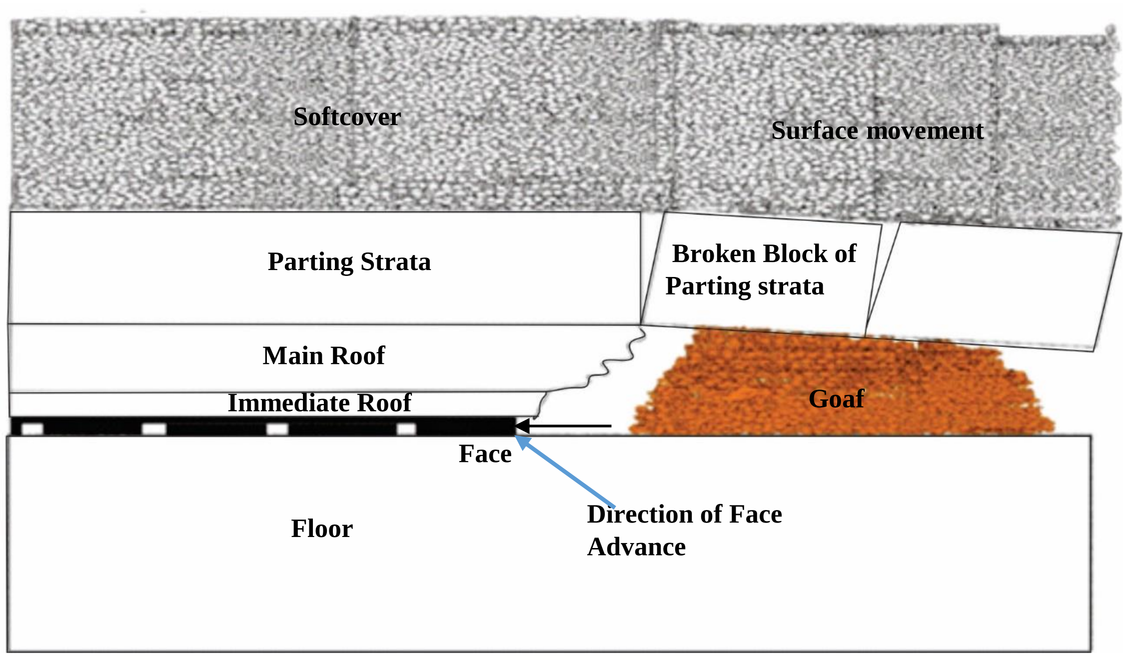

Fig. 1.1. Schematic diagram of depillaring under softcover

Many coal reserves are blocked under the influence of the soft overburden dump, as depicted in Table 1.1. In the coming time, the issue of loading due to softcover is likely to prevail in almost all the coalfields in our country. Practicing underground mines are already there, but the engineering design based on a scientific knowledge base is unavailable. The overall condition is resulting in poor ground control, uneconomical mining operation and foreclosure of mines.

Table 1.1. List of underground workings under softcover

Sl. No.	Coalfield	Mines	The backfilled Pit of Opencast mine	Total depth of UG working, m	minimum hardcover (HC), m	maximum softcover (SC), m	HC/SC
(a)	Chirimiri	Kurasia	Kurasia	59	9	50	0.18
(b)	Ib Valley	Orient Mine 2	Lajkura	110	30	80	0.38
(c)	Jharia	Phularitand	Phularitand	112	42	70	0.60
(d)	Ib Valley	Hirakhand Bundia	Samaleswari	180	90	90	1.00
(e)	Jharia	Kuiya	Kuiya	93	49	44	1.11
(f)	North Karanpura	Piparwar	Piparwar	183	98	85	1.15
(g)	Talcher	Talcher (west)	Lingraj	178	110	68	1.62
(h)	Raniganj	Khottadih	Dalurbandh	147	110	37	2.97
(i)	Talcher	Talcher (west)	Anant	165	135	30	4.50

A proper understanding of the effect of the softcover on the loading behaviour of support pillars and the caving behaviour of strata is essential for assessing the severity of strata control risk in depillaring workings. It can also help quantify the critical thickness of parting strata and the optimum requirement of the goaf edge support for a controlled load transfer and a safer mining operation. This work seeks a solution for this national-level problem. The findings of this study are crucial and strategic for modern underground coal mining that co-exists with open-pit mines due to site-based operational compulsions.

1.2 Objectives and Scope

The objectives of this work are to

(a) study the influence of softcover on the caving behaviour of strata in a depillaring working, and (b) develop an approach for delineation of the safe thickness of the parting strata, and assessment of the goaf edge support requirement for a safer depillaring in such geo-mining conditions.

The scope of the present work is limited to developing a suitable approach for evaluating the effect of softcover on the caving behaviour of hardcover and the mechanism of load transfer during progressive extraction of pillars in a Bord and Pillar working. A numerical modelling approach has been developed to evaluate the effect of softcover on the strata control parameters such as load on the goaf edge support, goaf edge convergence, front abutment stress, and the goaf stress recovery in a depillaring working. The study considers the straight-line method of pillar extraction for a highly mechanised and faster working. A parametric numerical modelling study has been done to evaluate the settlement rate of the parting strata and the peak goaf edge convergence. This was correlated with the ratio of hardcover to the softcover for obtaining the safe thickness of the parting strata and the optimal capacity of the goaf edge support for safer extraction of pillars in the prevailing geo-mining conditions. The validation of the findings has also been done through a case study.

1.3 Methodology

The research methodology of this work comprises of literature review, a compilation of pertinent field data, formulation of numerical model and simulation scheme, and development of user-defined FISH sub-routines for implementing several tailor-made functions to meet the modelling requirements. Relevant data from various mining areas have also been compiled to design the experimental models and conduct parametric modelling studies. The parametric study results had been analysed to obtain the design criteria for evaluating the critical thickness of parting strata and the optimal support capacity for safer depillaring under softcover. The results have also been validated for a depillaring working at Kuiya Colliery, Jharia Coalfield.

1.4 Organization of the Thesis

Chapter 1 introduces the research work and its importance for the underground coal mining industry. It comprises of the general introduction, problem definition, objectives, scope and methodology of the work, and organisation of the thesis.

Chapter 2 explains the literature review of different aspects of strata control in depillaring workings. It discusses the findings of the strata behaviour studies conducted worldwide below conventional overburden and the softcover conditions and underlines the prevailing knowledge gap.

Chapter 3 illustrates the numerical modelling approach and its solution scheme, as developed in this work to study the effect of softcover on the strata and the goaf edge support behaviour during progressive depillaring.

Chapter 4 reports the results of the parametric modelling studies. It describes the effect of different variables on the strata and support behaviour parameters, like the front abutment stress, progressive caving behaviour, loading of the goaf edge support, goaf edge convergence and the compaction of cyclically filled goaf material.

Chapter 5 describes the design criteria for evaluating the safe thickness of parting and the optimal goaf edge support capacity for safer depillaring under softcover.

Chapter 6 includes validation of the findings for a site-specific condition. The effects of softcover on the span of main fall, goaf edge convergence, front abutment stress have been compared with the findings of the parametric studies and the work conducted earlier. The thickness of safe parting strata and the capacity of the goaf edge support have also been validated for the given geo-mining condition.

Chapter 7 presents the discussion on various aspects of study conducted in this work for assessing the effect of softcover on the caving behaviour of strata and delineation of the safe thickness of the parting strata, and assessment of the goaf edge support requirement for a safer depillaring under softcover.

In the last, Chapter 8 contains the significant findings of this study and the suggestions for future work.