International Journal of Mining Science and Technology xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

International Journal of Mining Science and Technology

journal homepage: www.elsevier.com/locate/ijmst

A review of cavability evaluation in longwall top coal caving

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ARTICLE INFO

Article history:
Received 30 November 2016
Received in revised form 5 February 2017
Accepted 7 March 2017
Available online xxxx

Keywords:
Longwall top coal caving
Cavability
Numerical modelling
Caving mechanism
Caving classification

ABSTRACT

Longwall Top Coal Caving has been considered as one of the most effective technologies for the extraction of underground thick coal seams. A large number of studies on the applicability of Longwall Top Coal Caving into new mine sites have linked the success of its application to the geomechanical understanding of the cavability of the top coal. The paper aims to improve the knowledge of the top coal cavability evaluation. Through literature, a range of parameters that affect the top coal cavability were first identified. Afterward, a number of cavability assessment methods and classifications were reviewed. The result is of importance that assists researchers in developing an advanced and reliable tool for the top coal cavability evaluation.

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1. Introduction

The underground extraction of the thick coal seam with thickness in excess of 4.5 m is faced with operational, technical, safety and economic problems. Several longwall mining methods such as Multi-Slice Longwall (MSL), High Reach Single Pass Longwall (SPL) and Longwall Top Coal Caving (LTCC) have been mainly applied to extract thick coal seams. Multi-Slice Longwall method divides a thick seam into separate slices that are extracted by a conventional longwall method. The method takes advantage of conventional longwall equipment; however, it suffers major disadvantages including operational costs and ground control issues. High Reach Single Pass Longwall is a conventional longwall method with a larger working height. The method has great benefit in the 4.5–5.0 m mining height range. When mining height exceeds 5.0 m, due to limitations such as equipment design and face conditions, this method has struggled to optimise productivity and to control face stability. Compared with other methods, LTCC offers a method that can extract up to 80% of the seam in the 5–9 m thickness range. The development cost per tonne is reported to be significantly reduced. Compared to SPL, LTCC results in improved face control, smaller and less expensive equipment, and improved spontaneous combustion control [1,2]. The method, however, is not applicable for all thick coal seams. Coal seam cavability, roof strata characteristics and high horizontal stress are examples of mining conditions that must be considered to attain a safe and effective LTCC operation [3].

Longwall Top Coal Caving was initially developed in the former Soviet Union and France in the 1950s and 1960s. It was then applied in the former Yugoslavia, Hungary, Romania, the former Czechoslovakia and Turkey [4–6]. The 'Soutirage' method which was developed in France in the 1960s [7] is considered as the original form of LTCC. The system includes a conventional longwall face operating at the base of a thick coal seam and the upper part of seam is extracted by caving (Fig. 1). This method faced major issues including dust and significant face disruption due to the top coal drawing [8]. After the mid-1980s, LTCC was abandoned in Europe. The major reason was that the levels of productivity from LTCC faces were less than that from conventional longwalls during that time. Since the late 1980s, LTCC has been introduced, developed and improved in China. The method is widely applied to extract thick seams in China with a significant innovation on equipment. The coal draw window was relocated to the rear canopy instead of being at the roof canopy while a second Armoured Flexible Conveyor (AFC) was designed behind the support base (Fig. 2). The improved designs of support and AFC and the additional extraction of top coal are the major differences between LTCC and a conventional longwall method. A conceptual model of LTCC is shown in Fig. 3. Recently, the Chinese mining industry has successfully developed LTCC equipment for the extraction of the 14–20 m ultra-thick seams with a cutting height up to 5 m [9]. The LTCC method for mining thick seams with large dip angles up to 41° has also been introduced in China with the top coal recovery rate up to 80% [10]. Apart from China, LTCC has been

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http://dx.doi.org/10.1016/j.ijmst.2017.06.021
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Please cite this article in press as: Le TD et al. A review of cavability evaluation in longwall top coal caving. Int J Min Sci Technol (2017), http://dx.doi.org/10.1016/j.ijmst.2017.06.021

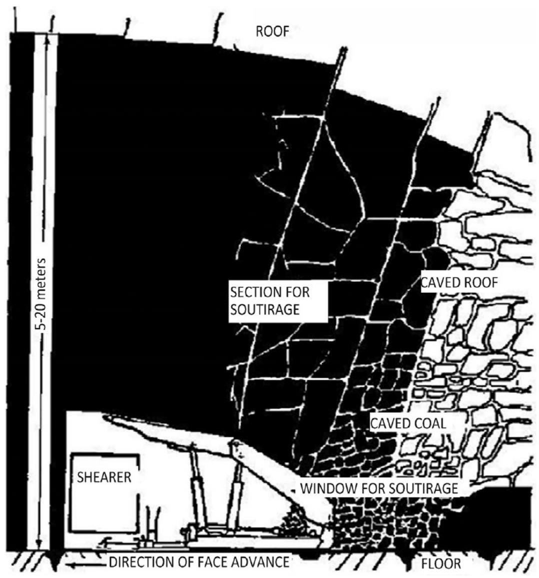

Fig. 1. 'Soutirage' mining method (after Schneiderman [7]).

employed in Australia and Vietnam [2,11]. Efforts are being made to introduce this method into India [12].

The successful application of LTCC in China in terms of productivity, cost and safety has promoted its application on a world scale. The variety of mining conditions in different countries requires the development of an engineering tool that can evaluate the LTCC applicability in various mine sites. The top coal cavability assessment has been the interest of LTCC studies. Empirical and observational methods have been widely applied to evaluate cavability in Chinese LTCC practices [5]. Various numerical modelling methods have been used to study caving mechanisms [6,13–18]. Physical models have been designed to understand the impact of overburden strata on cavability [19] or to study the top coal drawing [17,20]. Analytical solutions have also been utilised to analyse cavability [5,21] or face stability [22,23].

A number of cavability evaluation methods have been developed in literature [5,11,16,21,24]. However, there is no single method that can be universally applied. There is a need for an advanced and reliable assessment tool for various mine site conditions. A systematic understanding of the cavability controlling parameters and of the evaluation approaches is a necessary precursor to the development of any advanced cavability assessment method.

2. Parameters influencing top coal cavability

In a significant number of cavability studies, the evaluation systems are commonly derived from an understanding of the parameters that seem to have major impacts on caving performance. This section aims to analyse the effect of geological and geotechnical factors on the top coal cavability. These parameters can be categorised into four groups including coal seam characteristics, surrounding rock strata characteristics, stress conditions and others.

2.1. Coal seam characteristics

The coal seam characteristics which have been investigated in cavability studies mainly include the coal strength, coal discontinuities, coal cutting height and top coal thickness. The top coal cavability is an inherent characteristic that indicates the sensitivity and possibility of coal to cave under the action of strata abutment stress. The coal strength which indicates its resistant ability to fail-

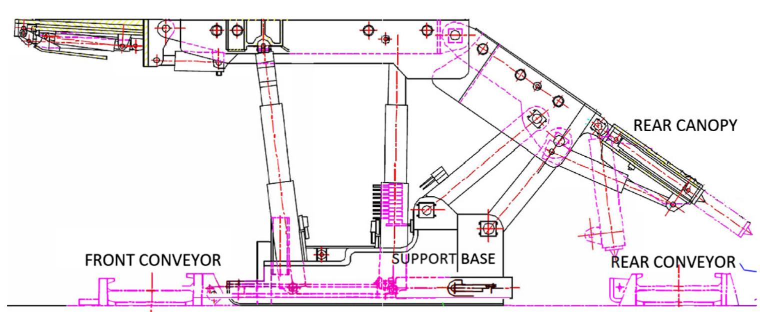

Fig. 2. LTCC support with double conveyors (after Xie and Zhao [13]).

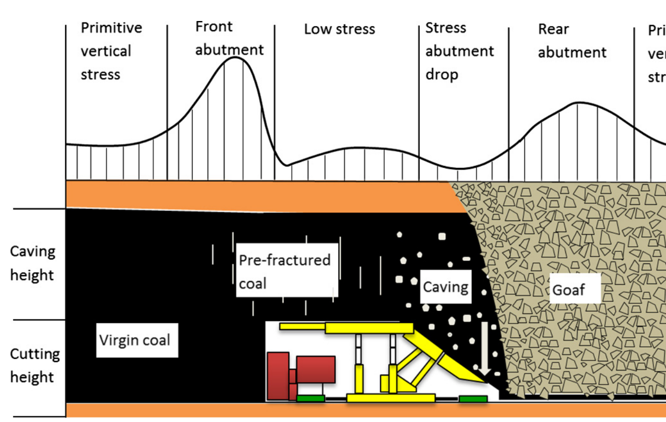

Fig. 3. LTCC conceptual model (after Xu [5]).

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