METHOD OF RIGID OVERLYING STRATA FAILURE ASSESSMENT OF EXTRACTED SEAMS AND ITS PRACTICAL APPLICATION

METODA HODNOCENÍ PORUŠOVÁNÍ PEVNÉHO NADLOŽÍ EXPLOATOVANÝCH SLOJÍ A JEJÍ PRAKTICKÉ VYUŽITÍ

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Abstract

The method of rigid overlying strata failure assessment of extracted seams is based on the simultaneous assessment of surface subsidence and seismic activity considering spatio-temporal progress of mining depending on the rock mass character and previous mine activity. If no complete failure of the firm overlaying layers occurs, the surroundings of the worked-out area is considerably supercharged and a risk of anomalous geomechanical phenomena occurrence substantially increases. The paper explains the mechanism of a rigid overlying strata failure under specific condition.

Abstrakt

Metoda hodnocení porušování pevného nadloží exploatovaných slojí je založena na současném hodnocení poklesů povrchu a seismické aktivity vzhledem k časoprostorovému postupu dobývání v závislosti na charakteru horského masivu a předchozí hornické činnosti. Pokud nedojde k prolomení pevných nadložních vrstev, je okolí vydobytého prostoru značně přitíženo a podstatně se zvyšuje nebezpečí vzniku anomálních geomechanických jevů. V článku je vysvětlen mechanismus porušování pevných nadložních vrstev v konkrétních podmínkách.

Key words: strutting arch, surface subsidence, extent of breakthrough, rigid overlying strata breakthrough, subsidence trough

1 INTRODUCTION

Due to the extraction of coal seams the original balance of rock mass is affected and a redistribution of stress occurs, i.e. changes in directions and size of applied main stresses appear. Around the mined out area, always a stress increase occurs, resulting in the compression of the goaf surroundings that reveals itself by a certain measurable surface subsidence. Determining the surface subsidence value with respect to the extent and thickness of the mined out coal faces is important to recognize the conditions under which a deformation of rigid overlying strata occurred. In many cases, a strutting arch is formed over the mined out area and no breach through the entire thickness of the unfaulted rigid overlying strata appears. During the formation of the strutting arch a high concentration load of rocks can occur and anomalous geo-mechanical phenomena can appear. However, also in cases when a breakthrough of an unfaulted roof takes place, the breakthrough extent does not require to be further extended by subsequent mining. Occurred overhangs of the unfaulted firm layers tailed into the non-undermined roof participate in the considerable surcharge of the affected area. The method of the roof failure assessment based on the measurements of surface subsidence conduces to a better overview of main roof failures of extracted seams.

2 DESCRIPTION OF THE ACTUAL STATE OF THE SOLVED ISSUES

Whether a complete failure of rigid overlying strata over the coal face has occurred or not, it is considerably affected by the size of stress applied around the coal face. Provided that any complete failure of the rigid overlying strata has not occur yet, then in the surrounding of the coal face a high stress is applied. This stress rises with increasing mined-out width. Theoretically, it is therefore possible to deduce a rigid overlying

strata failure from determining the above applied stress. To determine the stress in a rock mass the following methods are used:

- Deformometric method by means of discharging the drill core (overcoring),
- Direct stress measurement by hydrofrac.

Both these methods are considerably expensive and provide the information on stress in a certain place and at a certain time. For continuous findings of stress they are not relevant in terms of plant-scale.

Another method of the indirect assessment of the stress condition of rock mass is drill tests. This method, however, assesses the stress state at a small distance from the workings and does not provide the information on the total stress state of the rock mass.

The next method used for the evaluation of stress and deformation states of a rock mass is mathematical and physical modelling. The mathematical modelling of the rock mass, in which a process of longwall mining is in progress, is not so far at such level to be possible to find out, at which stage of mining a rigid overlying strata failure will occur. The physical modelling by the method of equivalent materials gives indeed a theoretical chance to determine the breakthrough of firm layers, but the model cannot take into account all considerable variety of affecting factors existing in the extracted rock mass. Moreover, it is a very expensive method, which was the reason, why it is not used under the given conditions in the Czech Republic any longer.

3 EXPLANATION OF THE PROPOSED ASSESSMENT METHOD GIST

In assessing rigid overlying strata under specific conditions we proceed as follows:

1. Data collection. The required information involves the results of periodic surface height measurements and the mine-engineering information on mining.
2. Data processing. The mine-engineering information must be spatio-temporally classified.
3. Data assessment. In assessing rigid overlying strata, it is appropriate to compare the measured values of subsidence with theoretical calculations, determine the mining factor and determine the time of a breakthrough that can be specified by a simultaneous assessment of seismic activity records. For the determined time of the complete failure, the coal face width and the characteristics of affecting factors are then specified for further processing.

The roof failure assessment according to the above procedure must be performed under various mining-geological conditions in order to be possible to process the database of the cases being assessed and carry out quantitative and qualitative assessments according to the following schema, Fig. 1.

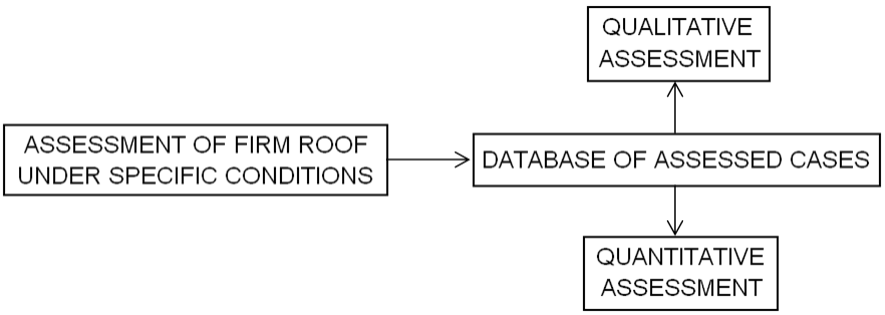

Fig. 1 Schema of the procedure of processing the assessment results for rigid overlying strata

As mentioned above, the method of rigid overlying strata failure assessment of extracted seams is based on the simultaneous assessment of surface subsidence and seismic activity considering spatio-temporal progress of mining depending on the rock mass character and previous mine activity. However, it is important, whether it is the retroactive assessment of earlier mining or the assessment of the actual state of rigid overlying strata failure of current mining.

Provided that the earlier mining is being assessed, when a coherent series of results of periodical altimetry, mine-engineering information and records of registered seismic phenomena are available, the assessment results are demonstrative and depending on the quality of input data precise. Such assessments provide the valuable information on the roof failure condition of the assessed seams for the whole period of mining, i.e. when the breakthrough of the rigid overlying strata occurred related to the width of goaf and when the overrun of overhangs of unfaulted carboniferous rocks occurred with respect to the spatio-temporal progress of subsequent mining.

A usable result of the earlier assessments is the determination of the coal face width at the time of breakthrough. Results from more localities then serve to the quantitative assessment depending on the mechanical character of roof of the seam being assessed and the mining depth. Another usable result of the earlier assessments is the qualitative processing of the gained data from the assessed localities, i.e. the determination of all affecting factors that can be characterized by an appropriate parameter. The qualitative assessment is processed individually, namely for the cases when a periodical roof failure of extracted seams occurred.

Unlike the assessments of the results of earlier extraction, the actual condition of the rigid overlying strata failure of actual extraction is assessed. Although resulting again from the measured values of surface subsidence and registered seismic phenomena, it is necessary to have also a good overview of the roof failure of the formerly extracted seams and assessment experience from similar localities. From this point of view, the assessment of the current failure condition is always a prediction, because the correctness of the actual assessment result proves itself only from the assessment at the time of the following measurement.

The assessment success of the actual state at the same time depends especially on relevant location of the surface points with respect to mining, frequency of surface measurements and on sufficient knowledge of natural conditions and mine-technical information on mining.

4 INPUT PARAMETERS FOR THE PROPOSED ASSESSMENT METHOD

The data collection for the proposed assessment method consists of the results of surface altimetry (Jiránková et al. 2009), geological information, geophysical measurements and mine-engineering information on mining (Jiránková 2008).

The mine-engineering information represents the data gained from:

- Basic mine maps
- Structural, mine, survey boreholes, e.g. geological profiles and determination of compressive strength, thickness and compactness coefficient of individual layers of unbroken roof
- Carbon contour maps
- Detailed tectonic maps
- Records of seismic activity in given areas
- Overviews of performed non-breaking large-scale blasting operations in given areas, or other methods of rigid overlying strata weakening

From the basic mine map, the information is obtained on thicknesses, dimensions and shape of mined-out areas, altitude of extracted parts of the seam, information on tectonic faults, state of monthly progress of the coal head. The geological information is gained from core boreholes; it is especially a macro-petrographic description of rocks and their thickness and lumpiness. The carbon contour map including the results of surface measurements is used for determining the cover thickness and thickness of overlaying carboniferous layers. The detailed tectonic maps provide the information on mutual position of tectonic faults with respect to mining. From the seismic records, the information is obtained on the location, time and amount of released energy of the registered phenomena. From the overviews performed by non-breaking large-scale blasting operations, the information is gained on the place and time of the shot of boreholes at the individual stages of non-breaking large-scale blasting operations, quantity of used explosive, borehole parameters (charging plan) and seismic effect of non-breaking large-scale blasting operations.

5 QUANTITATIVE ASSESSMENT

The result of the quantitative assessment of the achieved results is the determination of functional dependence between the goaf width (at which the breakthrough occurred) and the natural conditions characterized by the inflexibility coefficient (kn) of the rigid overlying strata and the depth of extraction.

The subject of further research is to process, by the proposed method of the roof failure assessment a sufficient number of localities, and to perform the quantitative assessment by the above described method. The assumed behaviour of the main lines is plotted in Fig. 2 in connection with the expected functional dependence between the goaf width and the inflexibility coefficient.

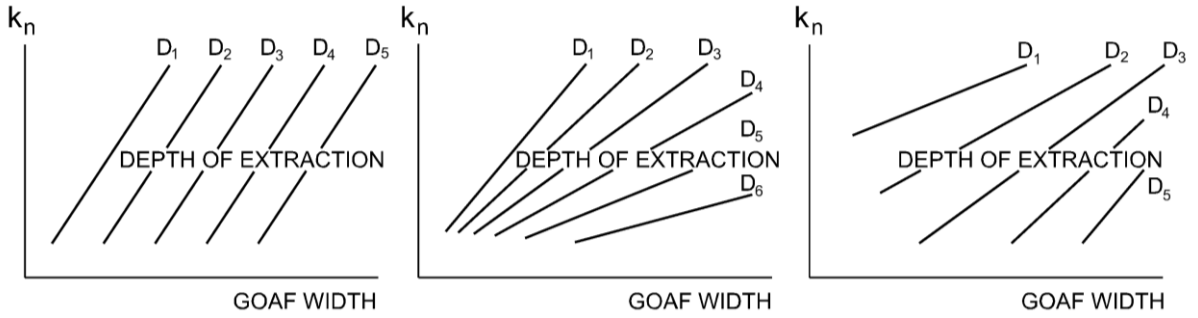

Fig. 2 The expected behaviour of main lines

6 QUALITATIVE ASSESSMENT

The qualitative assessment creates a knowledge database of the assessed cases. As already presented, by the quantitative assessment the functional dependence can be found only between the goaf width at the time of breakthrough, inflexibility coefficient characterizing natural conditions of the unbroken roof and depth of extraction. However, there is much more factors affecting during the mechanisms of failure. The qualitative assessment is based on these affecting factors that can be in some way classified. These are:

- Thickness of unbroken roof
- Number of interlayer interfaces of the unbroken roof
- Number of significant tectonic faults situated nearby the mining
- Depth of extraction
- Extracted thickness
- Number of boreholes of performed non-breaking large-scale blasting operations
- Mass of the used explosive during the large-scale non-breaking blasting operations
- Velocity of coal face progress
- Inflexibility coefficient

Further affecting factors involve the ruggedness and the shape of goaf that can be assessed only by comparison with the formerly assessed localities. The qualitative assessment must be also amended by the information on the strata members locating in the roof (Suchá, Saddle etc.) with respect to their different properties. The Saddle Member is formed predominantly from thick competent rocks and is characterized by a low number of bedding anisometry. These properties of the Saddle Member enable considerable stresses to be concentrated. Therefore, also the number of registered significant seismic phenomena in the Saddle Member is substantially higher than in the Suchá Member.

7 CONCLUSION

The method of the roof failure assessment is based on the simultaneous assessment of surface subsidence and seismic activity with respect to the progress of mining considering the mine-geological conditions of extraction. The result of the method is an interpretation of tensile deformations, which could cause a breaktrough of firm overlaying layers or vice versa such that a strutting arch would be created over the goaf, where a quasi-equilibrium stress state occurred. Another usable result of the assessment method is an interpretation of mined-out area dimensions, at which the breakthrough of firm overlaying layers occurred under specific conditions.

The method is applicable in such areas, where the mining is performed by the method of roof-controlled longwall working with an extracted thickness greater than 1 m. It is possible to use practically the found out functional dependence only in such areas, for which it was determined, e.g. for mines of OKD.

Currently the active or passive means of rock burst prevention are applied, in all successfully, in the area of the extracted seam and effective roof (seams rock burst are not practically recorded). The possibilities of prediction and prevention by active means for phenomena of a regional character with the place of occurrence in a wider surroundings and in a main roof are limited with respect to the complexity of this problem solution under OKD rock burst conditions. The method results serve in the area of geo-mechanics for completing the actual methods of rock burst prevention, in particular (with respect to the utilization of surface measurements for the assessment) in the area of a main roof. The result of the quantitative assessment should serve to plan and project mining activities.

ACKNOWLEDGEMENTS

The research presented in this paper was supported by the Grant Project no. SP2012/148.

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RESUMÉ

Metoda hodnocení porušování pevného nadloží je využitelná při hlubinném dobývání mocných slojí (s mocností větší než 1m) metodou směrného stěnování na řízený zával. Z výsledků hodnocení porušování pevného nadloží dobývaných slojí je možné posoudit, zda byly horniny pevného nadloží nad výrubem deformovány nebo se nad výrubem vytvořila vzpěrná klenba. Výhodou využití povrchových měření je možnost interpretace změn ve vyšším nadloží.