International Journal of Mining Science and Technology 25 (2015) 85–89

Contents lists available at ScienceDirect

International Journal of Mining Science and Technology

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

Analytical and numerical method assessing the risk of sinkholes formation in mining areas

Piotr Strzalkowski, Krzysztof Tomiczek *

Faculty of Mining and Geology, Silesian University of Technology, Gliwice PL-44-100, Poland

ARTICLE INFO

Article history:
Received 2 March 2014
Received in revised form 15 April 2014
Accepted 15 July 2014
Available online 7 February 2015

Keywords:
Mining exploitation
Discontinued deformations
Sinkholes
Stability
Risk of sinkhole formation
Tensile deformations of rocks

ABSTRACT

Voids, which have not been liquidated and associated with shallow mining excavations, pose a serious threat of potential formation of sinkholes. This threat is connected with the loss of stability of voids that had been formed as a result of mining operations in the deeper strata. Taking into account the impact of lower coal seams mining on shallow excavations and based on the example of a region that had been intensely exploited, this paper proposes a methodology for analysing the stability of shallow mine voids in the rock mass. Deformations in the excavation region were calculated by using FLAC2D computer program and assigning the Coulomb–Mohr model to the rock mass. Based on the numerical analysis, this paper evaluated the stability of the void in the event of a roof support fall. The results indicate the likelihood of void formation. Based on the Budryk–Knothe theory, the deformations of rock mass and sandstone strata in the roof of the void, which had been caused by mining exploitation in consecutive years, were calculated. The results of numerical calculations and analyses were compared with the limit deformations values of sandstone in tension. It is concluded that the exploitations cause the void to break down. The proposed method can forecast the discontinuous deformations threats in the areas that have undergone shallow undermining exploitation and the areas of underground urban.

© 2015 Published by Elsevier B.V. on behalf of China University of Mining & Technology.

1. Introduction

Upper Silesia, as well as many other European coal basins, has undergone mining exploitation for many years. Exploitation has begun with extraction of coalfields depositing at the shallowest level, and progressively mining works descended to the lower parts of coalfields. The loss of stability of shallow voids, which have often been associated with dog headings, resulted in formation of discontinued deformations on the surface, especially sinkholes. Generally, it has been assumed that sinkholes are formed as a result of self-supporting of voids located at the depth between 80 m and 100 m [1,2]. We still observe sinkholes formed due to loss of stability of voids, which is connected with mining operations carried out even in the 19th century [3]. It can therefore be concluded that the problem of sinkholes formation is still current and important, since sinkholes pose a serious danger to buildings that have been constructed on the surface [4–6]. There are many methods for predicting the formation of sinkholes [2], which also allow us to determine the probability of their occurrence. None of these methods, however, takes into account the impact of continued exploitations carried out in lower deposited coal seams on the stability of voids. This seems substantially important, because the area covered by shallow mining excavations in Upper Silesia – the largest urban area in Poland, is a relatively large area [1]. It seems too simplistic not to take into consideration the risk of sinkhole formation and the degree of rock mass deformations caused by successive mining. Such an approach has often led to the conclusion that the probability of sinkholes formation should suggest excluding an area from construction works [7,8]. On the other hand, considering the problem globally, sinkholes are formed occasionally. In the authors understanding, sinkholes are formed due to mining exploitations of shallow voids. In many instances, shallow exploitation was carried out in the 19th century and earlier, and its scope is often poorly documented. Many years of continuous exploitation of deeper coal seams must have caused loss of stability of voids and, frequently, have led to earlier formation of sinkholes. Their formation was not previously documented, and so the memory of them has not survived until today. Therefore, in many instance we have expected sinkholes occurring in areas where shallow voids already collapsed. This paper proposes a method of research that takes into account the impact of next exploitations on the possibility of formation of sinkholes [9]. The analyses have been performed on a selected practical example.

* Corresponding author. Tel.: +48 603794177.
E-mail address: k.tomiczek@hotmail.com (K. Tomiczek).

http://dx.doi.org/10.1016/j.ijmst.2014.12.003
2095-2686/© 2015 Published by Elsevier B.V. on behalf of China University of Mining & Technology.

The analysis comprises the following elements:

(1) Assessment of rock mass stability in an area of excavation. This analysis consists of numerical calculations, which enable to determine whether a void is still present in a rock mass if the roof support has been lost or damaged.
(2) Determination of the impact of further mining operations carried out in an area of a potential void on the rock mass in that area.
(3) Comparison of the values of calculated deformations caused by exploitation of deeper coal seams with the values of limit deformations in rocks deposited in the roof of an excavation [10,11]. Based on the above comparison, it can be determined whether the rock mass surrounding the void has lost stability and as a result the void poses a risk of collapse.

2. Exemplary assessment of the probability of sinkhole formation

The region under investigation comprised a residential area of detached and terraced houses. There is also a monumental building-the building of a church (Fig. 1), as well as buildings related to the liquidated shaft B-a building of the hoisting machine and the shaft top (Fig. 2).

2.1. Lithology and stratigraphy

Based on the borehole of shaft B, it can be concluded that the rock mass in the analysed region was made of the Quaternary overburden and coal measures strata. The Quaternary overburden is composed of soil and marl strata of a total thickness of 1.5 m. Carbon formation is made of Ruda Beds of coal seam group No. 400, saddle strata of coal seam group No. 500, and Porebski Beds of coal seam group No. 600. Carboniferous rock mass is made of alternating shale and sandstone layers, the thickness of which increases with depth.

The profile of geologic rock mass is shown in Fig. 3.

2.2. Completed mining exploitation

The subject of shallow mining exploitation in the residential area was the coal seam No. 349/1. This coal seam was exploited with the fall of roof at the height of 1.3 m between the years 1837 and 1859, at the depth of about 15.0 m. Based on the time of mining, it can be assumed that exploitation was carried out by using the shortwall mining method. According to the available sources (mainly archival mining maps), it can be concluded that the exploitation was carried out by the "Gute Amalie" mine, which began extraction in 1834. Then, exploitation in this area was carried out by KWK "M" mine. Fig. 4 shows a draft of arrangement of mining works in coal seam No. 349/1. Fig. 4 also presents the spot height of H_p in relation to the sea level, and the position of the calculating point selected for further analysis is marked.

Basic information about the geological and mining conditions of exploitation of successive coal seams of the analysed area is shown in Table 1. A schematic arrangement of mining fields, as in the order shown in Table 1, is presented in Fig. 5, which also shows the calculating point.

2.3. Assessment of stability of potential voids in the rock mass

In the light of recent experiences, dog headings pose the greatest risk of forming a sinkhole. The headings drilled at that time had dimensions of about 2 m × 2 m. It has been hypothetically assumed that such excavations were not removed and the wood lining that was then used was completely destroyed due to decay and rotting. The analysis of the degree of deformation in the area

Fig. 1. View of the church.

Fig. 2. View of the buildings of the hoisting machine and shaft top.

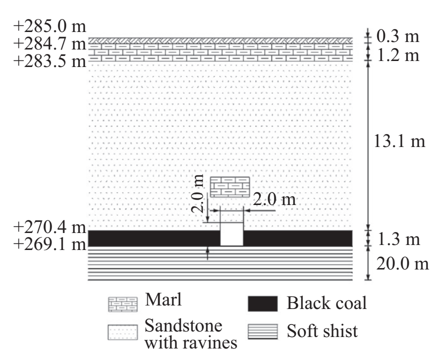

Fig. 3. Geological profile of the analysed area.

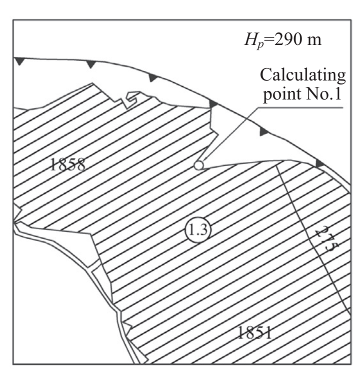

Fig. 4. Diagram of locations of mining works in coal seam No. 349/1.

Download English Version:

https://daneshyari.com/en/article/276479

Download Persian Version:

https://daneshyari.com/article/276479

Daneshyari.com