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The research of strain-stress state of magnetite quartzite deposit massif in the condition of mine “Gigant-Gliboka” of central iron ore enrichment works (CGOK)

Stupnik M.I.

D.Sc. in engineering

Kalinichenko V.O.

D.Sc. in engineering

Kalinichenko O.V.

Ph.D. in Economics

Muzika I.O.

PhD in Technical Sciences

Fed'ko M.B.

PhD in Technical Sciences

Pis'menniy S.V.

PhD in Technical Sciences
SHEI "Kryvyi Rih National University"

Abstract

The solution practical example of a problem of the massif strain-stress state determination and its strain for conditions of Kryvyi Rih basin mines with application of the specialized software is given. It is proved that the control of deformation processes of the rock massif and its state control according to geomechanics conditions are particularly relevant to the reduction of costs on mine openings protecting and operation and earth surface preservation in safety condition.

Key words: STRAIN-STRESS STATE, MASSIF, STRAIN, STRESS

The problem and its connection with scientific and practical tasks

The Kryvyi Rih iron-ore basin conducts the extraction of minerals using the open-cut and underground methods over 100 years. The systems of mining with the ore caving and the overlying rocks and with open cleaning space were used during production of iron ores using the underground method. The significant amount of cavities with a total amount over 100 million m^3 remained in the interior of the earth when using of mining system with open cleaning space.

About 30% of cavities, which remained after production of iron ores, were caved in course of time; they formed caving on a daylight area of zone. The cave-in, which is located in 50 m from the highway and 150 m from auto station, was formed in 2012 after the successive self-caving of bearing blocks and filling of cavity with the surrounding rocks in the Kryvyi Rih central district [5].

The area within mine allotment of the old mine n.a. Dzerzhinsky is one more dangerous place. Up to 1995, the mine produced the magnetite quartzites by surface chamber mining with interphase bearing block escape in three levels (380-300 m, 540-460 m and 710-630 m). There are mines technological complexes, local railway, Near-Dnipro Railways, housing and cultural and everyday welfare facilities within easy reach by mine allotment on a daylight area. Therefore, the control of daylight area condition, rock fault in the earth surface underworking zones of determination of massif strain-stress state around cleaning chambers is relevant significantly.

Researches and publications analysis.

It is known that the massif strain-stress state depends significantly on the degree of its heterogeneity, in particular, existence of structural, tectonic, tectono karstic and other troubles, which affect negatively the technological process of mining operations. There-

fore, the information on such troubles is extremely important both at a design stage and during the field development [6-7]. However, the experience of mining geophysics methods use showed that reliability of the rock mass monitoring can be provided with use of known methods in a complex only with new methods and technical means on the basis of progressive information technologies.

The computer modeling by numerical methods is one of progressive technologies of rock mass monitoring. Numerous methods of modeling consider the physical and mechanical properties of heterogeneous massif, and require the considerable capacities for the solution of problems of high computing complexity. This fact determines the efficiency of the modern computer equipment use for the problems solution of research, monitoring and forecasting of the massif strain-stress state when mining using various methods.

At the present time, there is a significant amount of application programs, which allow defining of the strain-stress state (SSS) of a massif [8-10]. Such programs include "SolidWorks", "Lira", "Ansys", "GTSNX", "SCAD" and some other. These program complexes allow investigating of a massif for continuous and elastic, as well as the elastic-plastic medium. The program complexes "SolidWorks", "Lira", "Ansys" may be emphasized in order to solve the problems associated with stress field determination, the massif deformation round the mined-out space. The conducted calculations according to the above considered program complexes showed the good reproducibility of obtained researches results.

Problem statement

In order to preserve the daylight area, it is necessary to estimate rapidly the actual stresses values in the massif, to predict the nature and reasons of their change during the entire period of the stope working. This will allow estimating of the existing conditions and obtaining of the basic data for improvement of applied and development of new technological schemes, selecting of optimum parameters of stope working and defining of their rational order.

The work objective is establishment of strain-stress state change regularities of the massif round the stopes at underground method of iron ores production and possibility of the rock massif strain-stress state control during iron ores production with use of consolidating stowing.

Statement of material and results

In order to estimate the impact of underground mining operations on a daylight area condition in the Kryvyi Rih basin and establish the opportunities for the computer modeling of the complex geomechanics processes in a massif, the researches of one of mining allotment problem areas of the old mine n. a. Dzerzhinsky, where in three levels (380-300 m, 540-460 m and 710-630 m), more than 40 chambers of several millions cubic meters total volume are worn, were conducted.

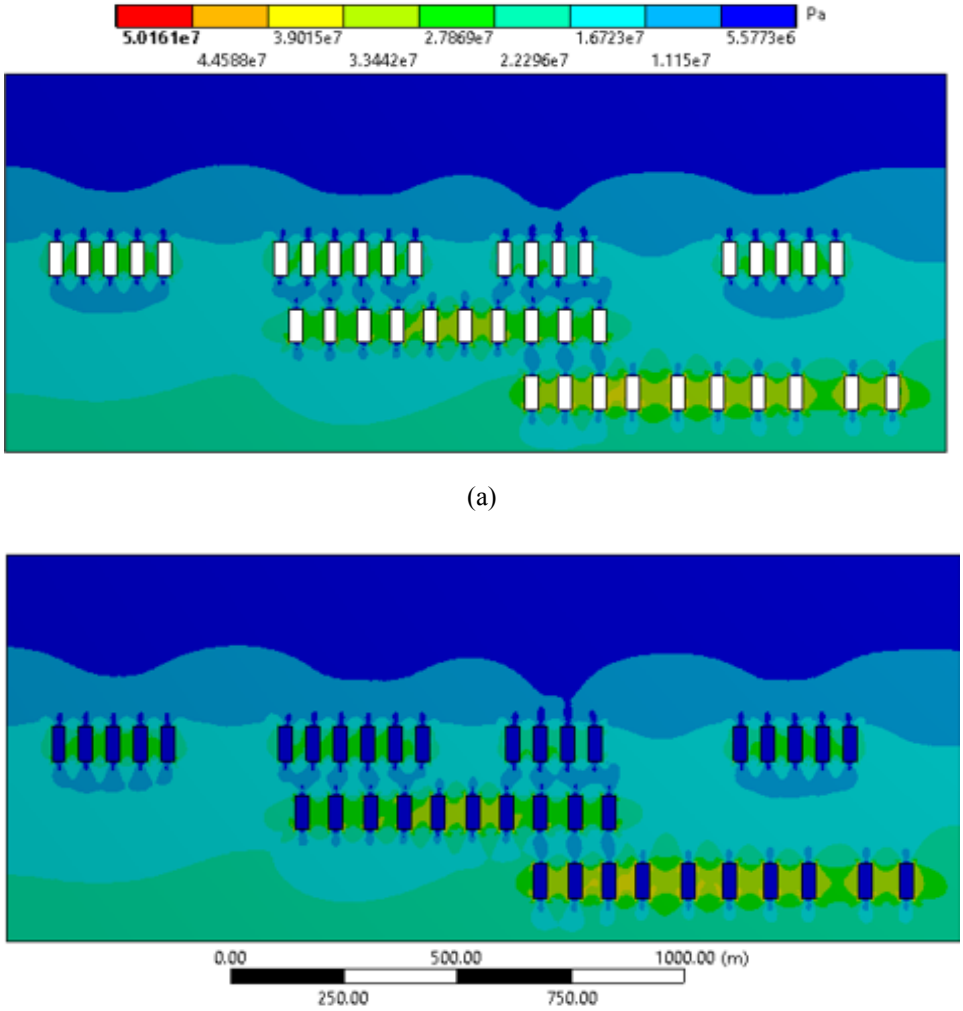
The research was conducted for the massif area, which length along the strike was more than 2.1 km and about 900 m from a surface to the depth. The calculation of stress and strain was carried out by means of the "Ansys" program of version 16.0. Modeling is executed for two cases: all the worn chambers are empty (as it is in reality) in the first case, and all the chambers are filled with the consolidating stowing in the second case. The main physical and mechanical and elastic properties of rock and material of stowing are given in the Table.

Table. Physical and mechanical properties of rock and material of stowing

Parameters	Rock	Stowing
Young's modulus, MPa	50000	500
Specific weight, kN/m^3	34.0	20.0
Tensile strength, MPa	14.0	0.2
Compressive strength, MPa	140.0	2.0
Poisson ratio	0.25	0.15

The 3D model was divided into quadrangles with a side size of 6 m in order to build the stresses and strains diagram using the finite elements method. The calculation results of a stress field of a massif with empty and filled with the consolidating stowing chambers are given below (Fig. 1, 2).

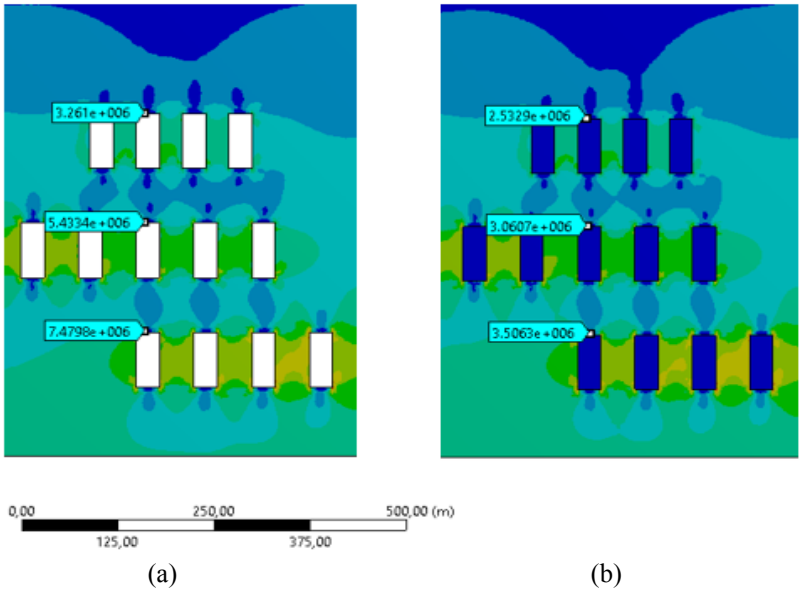
Apparently from the Figures, a maximum level of the compressing stress is recorded in angular zones of chambers without stowing, where it is 26-28 MPa. It makes only 18.5-20.0% of critical values for this type of rocks (that is the magnetite quartzites), that indicates the correctly chosen parameters of chambers and bearing blocks. It provides their long-term stability, which is actually confirmed by more than 30 years of experience of their existence. In case of filling of the worn chamber with the consolidating stowing, the level of stress in the bearing blocks and surrounding massifs is less by 11-16%.



(a)

(b)

Figure. 1. Isolines of stress: a) empty chambers; b) chambers with stowing

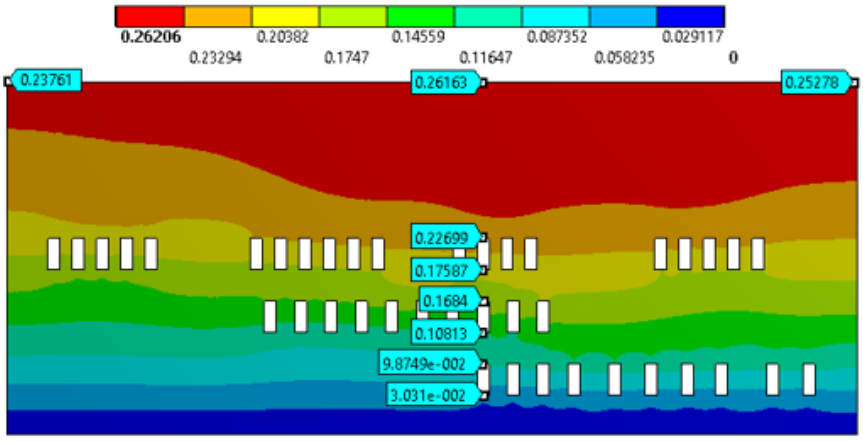


(a) (b)

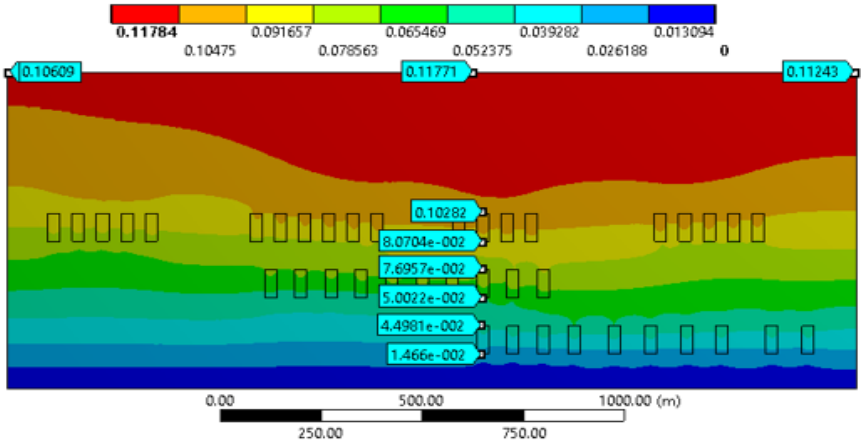
Figure 2. Stress isolines of the block central part with the specified sizes in a chambers deck: a) empty chambers; b) chambers with stowing

The maximum strains level takes place on a daylight area in the central part of a massif area, which was modeled: it is about 262 mm in empty chambers, and only 118 mm in chambers with stowing; that is 2.2 times less (Fig. 3).

The obtained data on daylight area "subsidence" above the areas of underground mining operations are in agreement with results of day instrumental monitoring over the vertical shifts conducted in our region by A. E. Kulikovskaya [11-14].



(a)



(b)

Figure 3. The diagram of a massif strain: a) empty chambers; b) chambers with stowing

According to its data, the earth surface strain in the Kryvyi Rih basin is recorded at a distance of 4.5 km from the mining operations area. The vertical shifts sizes reach to 275 mm at the most dangerous areas, and the relative rate of the surface subsidence can reach 8-10 mm/year. That is, the results of modeling are realistic and the developed model can be applied for predicting of further development of these processes.

Conclusions

On the one hand, the established level of daylight area "subsidence" is rather significant, because there is an intensive housing building and many objects of city infrastructure on a surface of this area (in particular, roads, different communication lines). They do not allow daylight surface to be damaged for avoidance of their destruction. On the other hand, considering the radius of curvature of this shift, we obtain that vertical shift is only 1-2 mm on 100 m of a horizontal surface. This does not cause any destructions, as it is much smaller than strain critical sizes (ε = 1.0 mm/m) according to the building regulations for buildings and constructions, which are located in the worn territories [15]. But thus, the time is one of essential factors which will be conductive to the further subsidence of the earth surface on this area. If the strains develop in time as well as till now, it is most likely that they will not constitute any threat.

Also, it is necessary to consider that there are about 200 million tons of reserves of high-quality

magnetite quartzite, which can become the further field production project site, in a subsurface resources of an above-mentioned mine allotment site. In that case, the balance of this litosystem is disrupted and the increase of volumes of the empty cavities (worn chambers) may pose the potential threat. Modeling of such situation is planned to be carried out at the next stage of researches. Also, it is planned to investigate the strain level of a daylight area of cross-wise field, where according to our assumptions, the difference in surface subsidence will be more significant, and where the existing caving zone from advancing mining of rich iron ores has a significant impact on geomechanics processes in a massif. This zone is arranged in the hanging deposit side of magnetite quartzites.

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