ANALYSIS OF STRESS AND STRAIN CONDITION OF ROCK MASSIF AROUND THE SPECIAL PURPOSE ROOMS USING NUMERICAL METHOD

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ABSTRACT: the investigation concerning selection and substantiation of special purpose room dimension designed for locating underground dressing mills in condition of magnetite quartzite deposits. Special purpose rooms are the rooms of great dimension designed for locating underground dressing mills, large underground grinders, plants, oil storage tanks, etc.

As stopping chambers and special purpose rooms have three dimensions and numerically slightly differ from each other under ore mining, stress condition of rock massif was studied in extensional position. While studying stress and strain condition of rocks around the workings, potential and finite-element methods were used taking into account the versatility and simplicity of their solution.

Boundaries of influencing edge room on stresses in mid plane surface of the rooms were determined. Conclusions are made about the fact that if the length of the working is three panels, the further increase of the length doesn't influence on stress and strain condition of mid plane surface.

Solution in condition of plane problem and solution in extensional position were compared Stresses while solving extensional and plane problems are similar as removing from the working. Replacing extensional condition by the plane one for rooms of limited length gives the error of about 20%.

The choice of room configuration of underground dressing mill meeting condition of long-term strength was made. Parallelepiped and cylindrical rooms were studied. The analysis of given results showed that the way of stresses distribution for selected room configuration is similar and numerical values of stress component have 10% difference in some points.

The strength of stopping chambers within sloping bed in extensional position was determined. The results of solution were compared with solution for horizontal seam with the rooms in the same conditions. It was stated that stresses in the centre of room panels of horizontal and sloping beds are slightly different.

Recommendations concerning selection of room configuration for locating there underground dressing mill in condition of magnetite quartzite deposits are given.

1. INTRODUCTION

Until recently the Earth surface seemed to be infinite and only lately people began to discuss the problem how to protect it. Population density on the areas suitable for resettlement is noticeably increasing.

The usage of underground area is one of the methods of exploiting natural resources. Problems concerning land reclamation, preservation and rational use of fertile soil layer while developing mineral deposits, carrying out geological, construction and other types of works are connected with the necessity of using underground area for household needs. Development of combined production providing complete and complex usage of natural resources, raw material and goods will allow exclude or significantly reduce negative influence on environment.

To protect the environment against negative influence of industrial enterprises heavy equipment required for ore extraction and processing, plants and factories, refrigerators, parking houses, oil storage tanks, power stations, etc is located underground within current or specially created workings.

Analysis of choosing and substantiating special purpose chamber dimension in extensional manner by creating underground dressing mill for magnetite quartzite deposits is given.

2. PROBLEM STATEMENT AND SELECTSNG METHOD OF SOLUTION

As special purpose chambers are usually of great dimensions and have a complicated shape where it's hard to find cross-section corresponding to the plane problem , strength study of such chambers is reasonably to carry out in volumetric manner.

The necessity of using extensional problem statement appears also when combined development of interactive seams is taking into account. Sequence of extraction depends on rock pressure manifestation when stope face in combination with development workings represents extensional system. It's very hard to find there cross-section corresponding to the plane problem when mining and geological conditions are changed under mining operations.

Until recently the basic methods of strength analysis of large dimension chambers was based on the dome of natural equilibrium in the plane position which allow solving only narrow range of tasks.

To study rock stress-strain condition around workings various methods and approaches are used while solving problems concerning mining mechanical engineering..

Thus, analytical methods of solving extensional problems are widely used. A number of authors uses analytical methods to determine stresses taking place within the roof rock above coal seam close to stope face (Tsyrulnikov 1981), to find the shape of the working in massif weakened by the number of identical workings located far enough from the Earth surface (Mirsalimov 1979).

Experimental and analytical methods are an important trend in developing theory of space problem taking into account the complexity of describing real rock massif. Stress-strain condition nearby the working is determined by these methods using full-scale measurements of shifting working counter (Grytsenko and Vlasetnro 1977). Regularity of stress distribution is established and determined in the laboratory conditions on the volumetric photoelastic models (Vloh et al. 1978).

Problems of mutual impact of mining workings in volumetric manner studied with the help of models (Maruashvili 1981) where comparison of volumetric and plane models and results obtained with their help are given. Study of stress field around workings by optical method using laser installation allowed getting stress hologram around volumetric models.

However, it's impossible to build complete stress field and deformations using current experimental methods. In this case it's also necessary to use numerical methods of study which allow adding experimental results.

Method of finite elements is widely used while solving problem of mining geomechanics. This method enables to change internal and external area boundaries, environment properties, set various boundary conditions within a single algorithm that gives an opportunities to apply it in three-dimensional elasticity (Zienkiewicz and Taylor 2000).

General volumetric theory began intensively develop on the basis of integral equation theory which is laconic and ensures versatility. It became possible to solve a wide range of volumetric problems with the appearance of the theory of multidimensional singular integral equations. At present sufficiently completed potential theory is created (Kuprazde et al. 1976).

It's possible to come to the conclusion that the problems concerning massif stress-strain condition have a great number of solutions built up on the basis of various problem setting approaches and different methods of its solving. Versatility and simplicity of solutions while studying rock stress-strain condition around workings, to our opinion, gives potential method (Veryudgskei 1978) and method of finite elements which were used in this paper.

3. STUDY OF STRESS ROCK CONDITION AROUND CHAMBERS

Until recently volumetric problem solving was carried out mainly relating to stress study around capital workings of small dimension and series of coal strata. While developing ore deposits it's necessary to determine stress condition of stope chambers and special purpose chambers under the conditions of volumetric stress condition when three chamber measurements differ little from one another.

Series of problems for chambers of various relationship between span and the length: 1:7, 1:5, 1:4, 1:3, 1:2, 1:1 were solved to determine the influence of chamber end on stresses within medial plane.

Chambers have the height of 6 m, bay of 6 m. Physical and mechanical rock properties are the following: elasticity model is $7 \cdot 10^3$ MPa, Puasson coefficient is 0,2, specific gravity is$2 \cdot 10^4$ H/m^3 .

While analyzing results the following conclusions were made. If the length of the working is equal to three spans, then further increase of the length doesn't change stress-strain condition of medial plane. While solving problems concerning chamber stability with the length of less then three spans, it's necessary to use volumetric calculation scheme..

Correlation result of solving in plane and volumetric manner was carried out..

Recommended chamber dimensions of underground dressing mill are follows: span is 15m,length is 15 m, height is 30 m, arch height is 5 m. Similar correlation of dimensions demands to solve the problem in volumetric manner. Physical and mechanical properties of the rocks which are used while problem solving were determined: failure stress on compression is 155 MPa, on tension is 19 MPa, specific gravity is $3,3 \cdot 10^4$ н/m^3, elasticity module is $7 \cdot 10^4$ MPa, Puasson coefficient is 0,17, structure coefficient is 0,5. Mining depth is 650 m.

In calculation scheme left and right boundaries are fixed against horizontal shifting, and low boundary is fixed against vertical displacement.

Upper boundary is loaded by the weight of overlying rocks. The scheme is represented by the single working in rock massif (Fig.1) Stresses are calculated in the center of the roof and chamber walls.. The action of tangent stresses in the corners is reduced by means of their radius.

Problem solving in volumetric manner was compared with solution in the plane one for similar cross-sections. The results of correlation are given in Table 1.

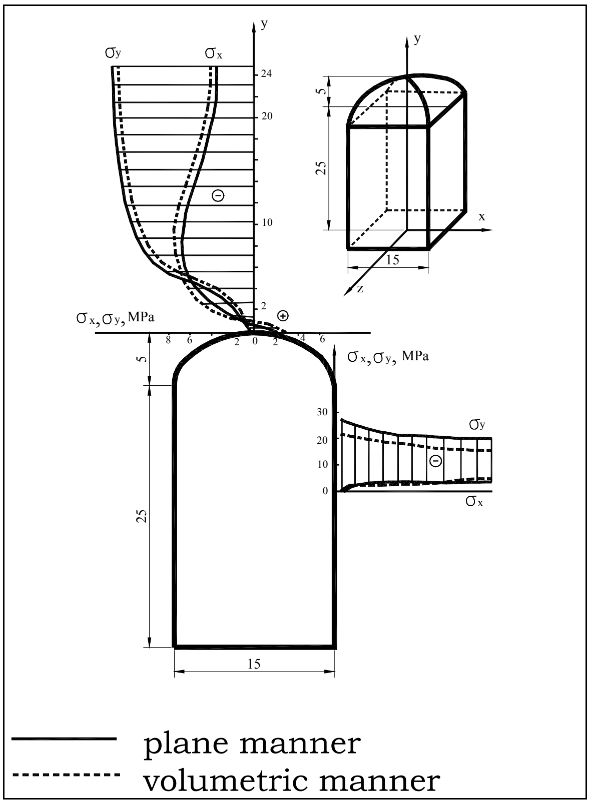

Fig.1. Correlation results of problem solving in plane and volumetric manners

Table. 1. Results of stress calculation around chambers of dressing mill in volumetric and plane manners

Plane manner		Volumetric manner	
σ_x, MPa	σ_y, MPa	σ_x , MPa	σ_y, MPa
In the roof			
2,39	-0,32	2,86	-0,20
-0,30	-0,63	-2,21	-0,41
-3,60	-1,90	-5,20	-2,10
-5,50	-3,50	-6,55	-3,20
-6,60	-5,30	-7,12	-5,00
-7,10	-6,90	-7,34	-6,70
-7,30	-8,50	-7,37	-8,30
-6,82	-12,2	-6,89	-12,0
In the sides			
0,62	-26,70	0,40	-21,12
-0,89	-24,28	-0,75	-21,05
-1,98	-23,59	1,47	-20,54
-2,50	-23,41	-2,30	-19,28
-2,70	-22,40	-2,95	-16,97

The following conclusions were made according to the study. The character of stress distribution around workings in volumetric manner is close to the character of stress-strain condition in plane manner. Stress distribution in the plane surface of the roadway side little differs from results of plane problem solving. Maximal compression stresses σ_z, the value of which is reduced while removing from the working take place in the chamber sides. Stresses σ_x and σ_y increase while moving to the center of the roof. Maximal compression stresses σ_x take place in the medial part of the working.

As removing from the working stresses are close while solving plane and volumetric problems. Replacement of volumetric condition by the plane one for chambers of limited length gives the error of about 20%.

Chamber dimensions of dressing mill are given according to the certain technological considerations and can be changed within restricted limits. Chamber form can be various. To choose chamber form corresponding to the long-time strength, chambers which have the form of parallelepiped and cylinder were studied (Fig 2).

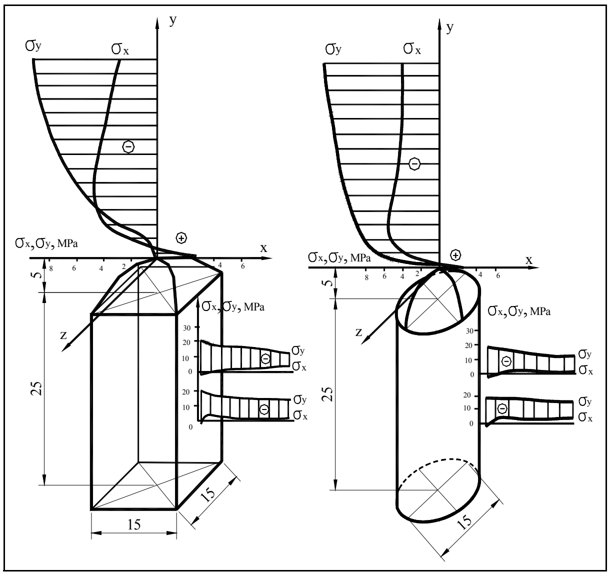

Fig. 2. Selecting chamber form at underground dressing mill

Chamber dimensions are follows: cross-section radius of cylindrical chamber and the side of chamber bottom in the form of parallelepiped is 15 m, chamber height is 30 m, arch height is 5 m. Result solving for chambers of various shape is given in the Table 2.

As chamber cross-sections have regular geometrical bodies, then longitudinal sections parallel to the areas *y0x* and *y0z are in the same conditions and their stress-strain condition is the same too.*

Analysis of the results showed that the character of stress distribution for given chamber forms is the same and numerical values of stress component slightly differ.

Table 2. Stress values for chambers in the form of parallelepiped and cylinder

Parallelepiped		Cylinder	
σ_x, MPa	σ_y, MPa	σ_x, MPa	σ_y, MPa
In the roof			
2,86	-0,20	2,55	-1,10
-2,21	-0,41	0,14	-6,40
-5,20	-2,10	-7,28	-6,70
-6,55	-3,20	-6,79	-6,90
-7,12	-5,00	-6,90	-7,50
-7,34	-6,70	-6,61	-10,1
-7,37	-8,30	-6,40	-11,0
-6,89	-12,00	-6,39	-12,3
In the sides			
0,40	-21,12	0,43	-19,30
-0,75	-21,05	-0,35	-19,07
-1,47	-20,54	-1,20	-18,08
-2,30	-19,28	-2,10	-16,11
-2,95	-16,97	-2,60	-13,07

Maximal tension stresses σ_x and σ_y take place in the center of roof chambers.. In this case tension stress for cylindrical working is 2,55 MPa and for the one is 2,86 MPa, e.g. the difference is 11 %. While moving from the chamber roof stresses for both types of workings differ a little. Maximal strain stresses σ_z take place within chamber walls and they are 19,3 MPa for cylindrical working , and they are 21,1 MPa for parallelepiped one. It gives the difference of about 10%.

In whole components of stress-strain rock condition for cylindrical working are lower.

After robbing newly formed chambers can be used for warehouse, equipment, etc. location. So, stopes can be used as special-purpose ones. Underground dressing mill can be allocated there as well.

Calculation in volumetric manner using potential method was made to determine the strength of stope chambers within inclined seam.

Calculation scheme is represented by isotropic rock massif weakened by the number of the holes. Fig.3 shows calculation scheme answering condition of periodicity of the problem and stress epure.

The following initial data are taking into account: chamber height is 30 m, width is 15 m, length is 15 m, arch height is 5 m, chamber width is 20 m, elasticity modulus is $7{\cdot}10^4$ MPa, Puasson coefficient is 0,17, specific gravity $3{,}3{\cdot}10^4$ n/m^3, mining depth is 650 m. Angle of seam slope is 60°.

The results of the study are in the Table 3. Stress epures are built according them (Fig. 3).

Result solving is compared with solution for horizontal seam with chambers in similar conditions. It was determined that stresses in the center of chamber span of horizontal and inclined seams slightly differ.

Maximal strain stresses take place in the rocks of hanging wall and differ from maximal strain stresses within chamber walls of horizontal seam on 18%, from stresses within the rocks of bottom wall on 13%.

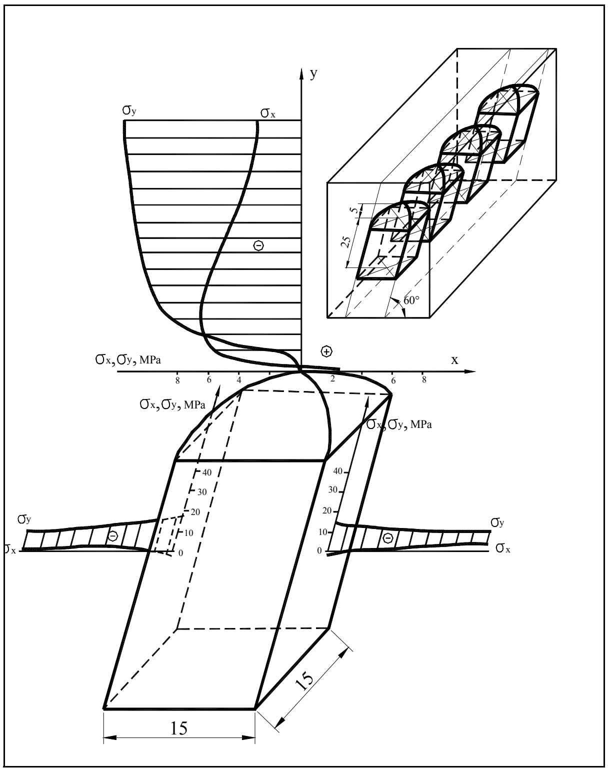

Fig. 3. Stress epures for stoping chambers within inclined seam

Safety margin for given sizes answers the condition of long-term construction and chamber strength being in the similar conditions. They can be used for allocating dressing mill equipment.

Table 3.Solving results for stoping chambers within inclined and horizontal seams

Inclined seam				Horizontal seam	
σ_x, MPa		σ_y, MPa		σ_x, MPa	σ_y, MPa
In the roof					
2,67		-0,07		2,94	-0,20
-2,11		-1,88		-2,21	-0,41
-4,79		-4,62		-5,20	-2,10
-5,85		-7,08		-8,55	-3,20
-6,19		-9,04		-7,12	-5,00
-6,24		-10,6		-7,34	-6,70
-6,17		-11,9		-7,37	-8,30
-6,06		-12,3		-6,89	-12,0
Within the walls					
Hanging wall	Bottom wall	Hang-ing wall	Bottom wall		
2,04	1,34	-16,33	-14,24	1,20	-20,02
1,92	1,14	-16,26	-13,90	1,90	-17,50
1,34	0,44	-16,12	-13,50	0,34	-17,14
0,56	-0,54	-15,82	-12,94	-0,75	-17,02
-0,25	-1,69	-10,09	-11,99	-2,39	-14,20
-1,04	-2,90	-10,55	-10,36	-2,75	-12,39

4. CONCLUSIONS

In a whole the problem solving showed that stressed in the roof of the chamber while solving in volumetric manner are bigger then in the plane one. It is connected with the fact that in volumetric manner chambers have commensurable dimensions and stresses in the center of the roof are increased by the closeness of angles with the great stress concentration. As corner radius in the parallelepiped chamber leads to creating chamber close to cylindrical one, and stress difference in the center of cylindrical chamber roof and while solving plane problem is less then 2% then it confirms the conclusion about stress concentration influence in the chamber corners.

Stresses within chamber walls while problem solving in volumetric manner less then in the plane one. It can be explained by the fact that in volumetric solution of the problem rock weight above the chamber is distributed within rock massif from four chamber sides and in the plane manner of solution it is made from two sides..

Error is about 20% for maximal stresses while replacing volumetric state by the plane one.

It is found out that stresses in the center of chamber span of horizontal and inclined seams are slightly different.

Results of the study were used by designed institutions while making project decisions as for creation of experimental and industrial area of underground dressing mill in condition of iron ore deposit.

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