DISTRIBUTION OF SECONDARY STATE OF TENSION AROUND STOPES

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Abstract: *The hereby paper attempts at drawing out an analysis of the complex state of tension that occurs at the level of stopes. The analysis is grounded on the finite elements numerical modeling of subsidence measurements and their transfer to underground mining. The main objective of the paper is the analyzing of the state of tension in stopes displaying a single preparation gallery or two preparation galleries.*

1. The state of tension occurring in stopes

The analysis of tensions' distribution around stopes is quite complex and difficult, due to the large number of parameters that have to be observed. Attempts at studying the phenomenon through mathematical investigations have been limited to its analysis within an elastic environment.

Satisfactory results have been obtained while employing the optical-polarizing or photo-elastic method [1], [2], [3], [6], [9].

Lately, research has been directed towards the mathematical modeling with finite elements, frontier elements or their combination [8].

In order to analyze the influence of exploitation upon the rocks massif, a series of quasi-static issues corresponding to the exploitation stages should be settled. These issues require a thorough settling due to the fact that an exploitation stage starts from data to limit and initial information having resulted out of a previous stage.

With the advancement of the stope, the complexity of the issues grows, due to the fact that, within the influence field of the rocks massif, a series of sub-fields come out, displaying rocks that are broken or strongly cracked. Meanwhile, slip plans come out, which should be considered as discontinued surfaces within the influence field.

The work schedule of the main roof exhibits the following two cases:

1. The case of the initial movements of the roof, which includes one cycle, starting with the first deformations of the roof, determined by the digging of the pre-stope, to the first crumbling of the main roof. In such a case, the whole perimeter of the excavated area displays support pressure, which is transmitted downwards, from one rock package to the other.
2. The case of the subsequent movements, when the movement of the covering rocks is periodical and repeated after certain cycles, depending on the type of the roof rocks.

In the case of a high value of the length of the working area, the process of breakage of the covering formations sometimes extends up to the surface. In the case of a decreased value of the length of the working area, this process does not extends towards the surface, but stops at the level of a resilient layer of rocks, which is able to preserve its stability. A series of researchers [5] have shown that, when dealing with the horizontal layers exploitation of the thick coal strata through directing mining pressure owing to meltdown, several areas of deformation and movements of the roof's and hearth's rocks may occur.

The researches dealing with the exploitation of the 3rd layer in the Jiu Valley, in the case of average and high inclining, have shown that [5] within the first area, the rocks collapse in smaller blocks, which lose their inter-connection and break while moving. The console of direct roof does not break at the level of each cut exploited, the collapsing step decreasing with the progression of the works towards the deeper layers.

In the case of the 2nd area, the rocks break in large blocks, delineated by secant fissures and plans parallel with stratification, without losing their interconnection.

The 3rd area includes the covering rocks, up to the surface, which may be disturbed by the exploitation of the layers located in the roof.

The issue implies the determining of the size and manner of acting of such a distribution upon preparation works. In order to settle such issues, one should consider a loading model displayed by figure 1 as well as the parameters of the model, which are exhibited by table 1.

2. Modeling of the state of tension through numerical methods

In order to determine the distribution, it is recommended to employ the model shown in analysis [7] and displayed by figure 1.

The planning of the model is also grounded, besides the characteristics of the rocks displayed in table 1, on the values of the dipping angles.

Figure 2 exhibits the dipping angles in the case of a thicker and significantly inclined layer. [4]

Figure 3 shows the limit angles downstream β_0, upstream γ_0, displacement angles from river deposits φ, conventional angles β and γ, and breakage angles β" and γ" .

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Table 1 *Characteristics of the rocks around the stope*

Appellation of the environment	Elastic characteristics of the rocks that are part of the analyzed environment	Mechanical characteristics	Breaking criterion
Fissured rock	E=13000 MPa μ=0.4	σ_c=54 MPa σ_t=13 MPa c=13 MPa φ=37°	***Mohr-Coulomb***
Crumbled rock	E=800 MPa μ=0.38	σ_c=2 MPa σ_t=0.5 MPa c=0.5 MPa φ=37°	***"No tension"***
Coal	E=1485 MPa μ=0.35	σ_c=2.3 MPa σ_t=1 MPa c=0.75 MPa φ=24°	***Mohr-Coulomb***

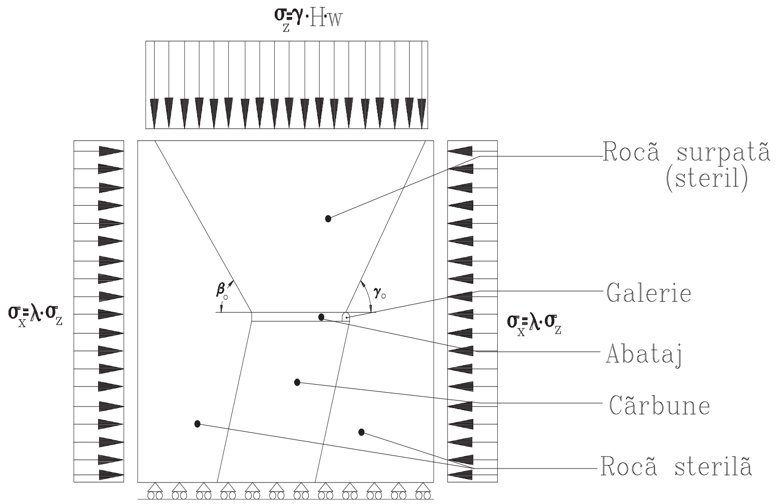

Figure 1. *Module of loading the model for determining the tensions in the context of stope's interaction with preparation works*

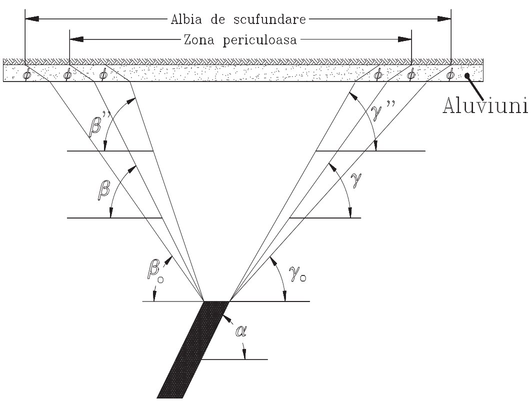

Figure 2. *Angular parameters*

The angles recommended with a view to drawing out the model are the limit angles β_0 and γ_0, which have been experimentally determined [4] for thick layers and own the following values: $\beta_0=47°\div50°$ and $\gamma_0=59°\div65°$.

Parameter w, figure 2, is a parameter that decreases the load of the mining work and observes the fact that it is not the entire weight of the rock column that acts upon the mining works. Such facts are valid for the mining works occurring at great depths. The hereby parameter owns a sub-unitary value, which may be 1, at its most, in the case when the crumbled area reaches the surface.

3. A case study

Let's consider a 50 m front stope, in a layer exhibiting a 48° inclination and a preparation gallery displaying a digging area of 13.41 m^2 ; (GDM 10) the secondary state of tension around the preparation galleries influenced by a stope, employing Mohr – Coulomb criterion of breakage for various values of λ, where w=0.8, are shown in figure 3 and table 2, in the case of the exploitation method involving a single preparation gallery in the hearth, and in figure 4 and table 2, in the case of the exploitation method involving two directional galleries.

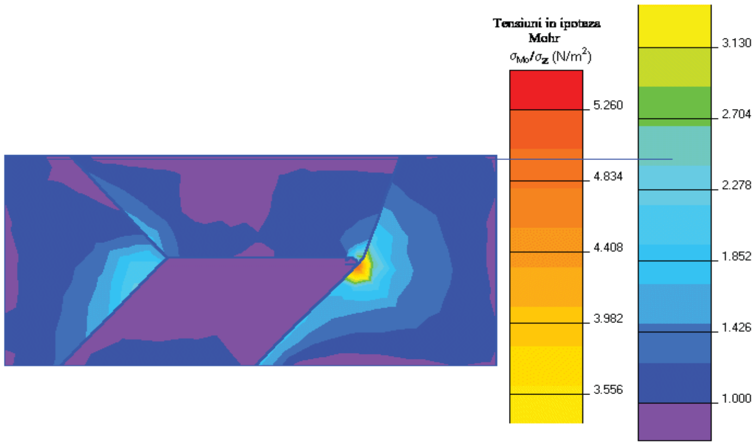

Figure 3. *State of tension according to Mohr hypothesis, when (σ_x=σ_z), in the case of the exploitation method involving one preparation gallery*

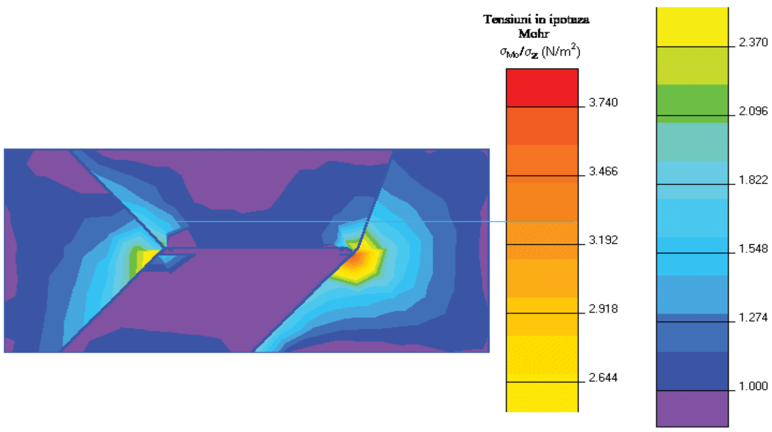

Figure 4. *State of tension according to Mohr hypothesis, where (σ_x=σ_z), in the case of the exploitation method involving two preparation galleries*

Table 2 *Value of the state of tension, according to Mohr hypothesis for various values of side push*

Exploitation method	Relation among the main tensions	Tension value σ_{MO}/σ_z [N/m^2]	
		Maximal	***Minimal***
With one preparation gallery	σ_x=0.2*σ_z	2.590	1.159
	σ_x=0.3*σ_z	2.690	1.169
	σ_x=0.4*σ_z	2.860	1.186
	σ_x=0.5*σ_z	3.110	1.211
	σ_x=σ_z	5.260	1.426
With two preparation galleries	σ_x=0.2*σ_z	4.830	1.383
	σ_x=0.3*σ_z	4.430	1.343
	σ_x=0.4*σ_z	4.060	1.306
	σ_x=0.5*σ_z	3.750	1.275
	σ_x=σ_z	3.740	1.274

4. Conclusions

The analysis of the figures displayed shows that increased tensions act around the galleries in the layer's hearth, a phenomenon that is both the result of the layer's inclination and of the angles at dipping limit.

The analysis of the models and of the figures exhibited determines the following results:

-Tension around the mining preparation works increases with the growth of side tension;

-The tensions around the preparation mining works are strongly influenced by the type of stope support; in the case of a mechanized support, stability is higher than in the case of individual support; maximal stability occurs in the case of an ideal support (an ideal support implies a maximum bearing support, which is required with a view to getting the stability of the mining construction);

-The tension determined by the stope results in a 2-3 units growth of the tension around the mining preparation works;

-Maximal tension is located in the hearth of layer 3;

Other parameters that influence the state of tension of the preparation works are the following ones:

-Parameters of crumbled rocks;

-Parameters of the rocks in the hearth and the roof of the deposit; (the higher the resistance of the rocks in the hearth and roof, the more stable the gallery);

-Location of the preparation galleries (inside or outside the crumbling cone);

-Exploitation method employed (stability increases in the case of the exploitation methods involving the lining of the exploited area, determining the decrease of the state of tension);

-Limit dipping angles;

-Inclination angle of the deposit;

-Vertical tension σ_z and, implicitly, exploitation depth.

As a result, in order to provide the stability of the preparation works, it is necessary to determine the deformation characteristics of the rocks as well as the manner of deformation of the mining works and the choice of a proper construction support required with a view to counterbalance the destructive effects of the states of tension.

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