Optimization of the constructive system lining of metallic support structures in order to reduce deformation speeds of horizontal mining works executed in deep layer sedimentary rocks

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Abstract: Mining works executed in deep layer sedimentary rocks, are exposed to large deformation speeds during exploitation, because of rock pressure applied on the walls, the ceiling and bedrock of excavations. In this paper, we aim to find a solution for optimizing the constructive metallic structures, and subsequent linings, through the improvement of the transmission way of loads originating in rock pressure. According to Panet – Sulem support/rock interaction, there is a possibility of guiding rock pressure through constructive support system.

1 Introduction

The deformation speed of horizontal mining works executed in deep layer sedimentary rocks, was studied and analyzed in detail at the Petrila Mining Works. In this paper, we will present the method of deformation of a directional gallery in the bedrock layer 3, block II, west/south-west area. The proposed constructive solution aims to lower the speed of deformation, and subsequently to insure non-deformability of the geometric structure. At the moment of measurement, the network of mining galleries was totaling 3555 meters. This network of mining works was passing through 33 % sandstone, 21 % clay, 29 % sandstone clay, 7 % marl, and 10 % coal clay.

2 Deformation speed calculus

The speed of metallic structure deformation on the basis of transmitted load by rock pressure, can be determined both by experimental ways and analytical methods [1-5]. From the studied perimeter of horizon 50, we analyzed the main transversal gallery and the directional ones from east/west and west, because this intercepts all the rock types present in the studied perimeter. For the analysis of deformation particularities, in each of the mining work, we arranged observation station marked with measurement marks of rock displacement in the ceiling, bedrock and wall, as in figure 1.

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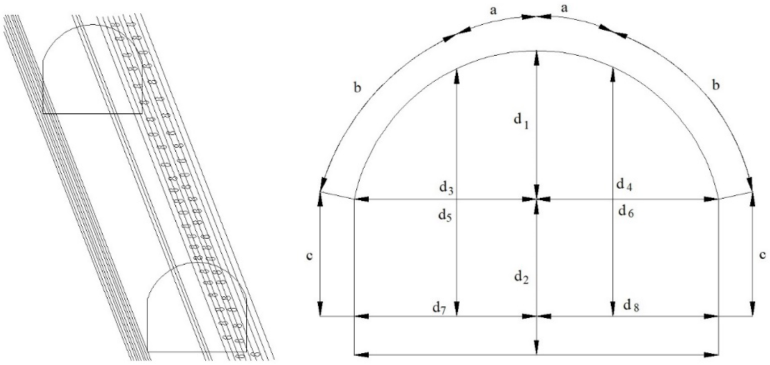

Fig. 1. Rock displacement marks.

For deformation speed calculus, the calculus relations are presented below.

We note with U_T the ceiling-bedrock deformation, which is calculated with the following relation 1 [6-9]:

$$U_T = (d_1 + d_2)_{STAS} - (d_1 + d_2)_{MAS} \qquad (mm) \tag{1}$$

Where: $(d_1 + d_2)_{STAS}$ is the height of the armed gallery profile, (mm);

$(d_1 + d_2)_{MAS}$ is the height of the subteranean measured gallery, (mm);

The deformation of the width of the gallery is noted with U_B and is calculated with the following relation 2 [6-9]:

$$U_B = (d_7 + d_8)_{STAS} - (d_7 + d_8)_{MAS} \qquad (mm) \tag{2}$$

Where: $(d_7 + d_8)_{STAS}$ is the width of the armed gallery profile, (mm);

$(d_7 + d_8)_{MAS}$ is the width of the subteranean measured gallery, (mm).

The deformation of the gallery bedrock is noted with U_V and calculated with the following relation 3 [6-9]:

$$U_v = Xv_{STAS} - Xv_{REAL} \qquad (mm) \tag{3}$$

Where: Xv_{STAS} is the distance from the bottom wire to the gallery bedrock according to the arming monograph;

Xv_{REAL} is the measured subteranean distance and is aproximated with the following relation 4 [6-9]:

$$Xv_{REAL} = (d_1 + d_2)_{MAS} - \left(\frac{d_5 + d_6}{2}\right)_{MAS} \qquad (mm) \tag{4}$$

The deformation speed which is noted with V_D will be calculated with the following relation 5 [6-9]:

$$V_D = \frac{U}{t} \qquad (mm/zi) \tag{5}$$

Where: U is the variation of deformation in the time interval between two consecutive measurements, (mm);

t is the time interval between two consecutive measurements, (days).

The ceiling, wall and bedrock deformation speed was noted with V_T, V_B, V_V.

3 Measurements and results obtained for the directional gallery situated in the bedrock of layer 3, east-west

For the directional gallery situated at horizon 50, the station placement is at 6 m from the intersection of the main transversal gallery, as professors N. Lețu, E. Marica, C. Semen and D. Chirilă described this procedure in their reaserch contract [10] (fig. 1).

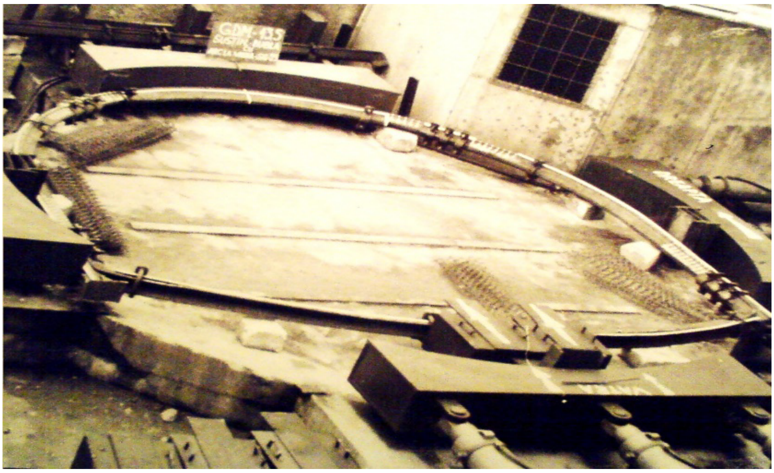

Fig. 2. The distribution of loads in laboratory testing.

The height of the armed profile gallery is (d1 + d2) STAS = 2430 mm.

The width of the gallery bedrock is (d7 + d8) STAS = 3600 mm.

The distance Xv $_{STAS}$=930 mm.

In the tables 1, 2 and 3 below it is illustrated the deformations values of the gallery measured in time.

Table 1. Deformations values measured in time.

Measurement date	**d_1**	**d_2**	**d_3**	**d_4**	**d_5**	**d_6**	**d_7**	**d_8**
17.03	856	1414	1275	1216	1700	1730	1465	1222
26.03	855	1265	1265	1195	1695	1725	1425	1000
06.04	855	1135	1240	1100	1657	1740	1380	1115

Table 2. Width deformations of the gallery.

Deformation registered in date	**U_T**	**U_B**	**U_V**
17.03	140	313	355
26.03	295	995	305
06.04	440	1105	638

Table 3. Bedrock deformations of the gallery.

Deformation speed registered in interval	**V_T**	**V_B**	**V_V**
1	14.08	7.45	13.63
2	16.11	12.20	14.63

4 Measurements and results obtained for the directional gallery situated in the bedrock of layer 3, west

For the directional gallery situated at horizon 50, the station placement is at 6 m from the intersection of the main transversal gallery.

The height of the armed profile gallery is (d1 + d2) STAS = 2430 mm.

The width of the gallery bedrock (d7 + d8) STAS = 3600 mm.

The distance Xv_{STAS}=930 mm.

In the tables 4, 5 and 6 below it is illustrated the deformations values of the gallery measured in time.

Table 4. Deformations values measured in time.

Measurement date	d_1	d_2	d_3	d_4	d_5	d_6	d_7	d_8
17.03	735	1382	1304	1325	1615	1614	1625	1445
26.03	800	1200	1300	1315	1595	1620	1610	1420
06.04	810	1225	1270	1325	1575	1625	1560	1430

Table 5. Width deformations of the gallery.

Deformation registered in date	U_T	U_B	U_V
17.03	323	530	428
26.03	350	570	458
06.04	395	610	493

Table 6. Bedrock deformations of the gallery.

Deformation speed registered in interval	V_T	V_B	V_V
1	3.36	3.63	2.72
2	5.00	4.44	3.68

5 The main transversal gallery

For the main transversal gallery situated at horizon 50, the station placement is at 6 m from the intersection of the main directional gallery east-west.

The height of the armed profile gallery (d1 + d2) STAS = 2900 mm.

The width of the gallery bedrock (d7 + d8) STAS = 4100 mm.

The distance Xv_{STAS}=1580 mm.

In the tables 7, 8 and 9 below it is illustrated the deformations values of the gallery measured in time.

Table 7. Deformations values measured in time.

Measurement date	d_1	d_2	d_3	d_4	d_5	d_6	d_7	d_8
17.03	665	1660	1410	1450	1558	1560	1745	1800
26.03	700	1635	1405	1445	1535	1500	1740	1896
08.04	700	1610	1400	1440	1530	1600	1740	1895

Table 8. Width deformations of the gallery.

Deformation registered in date	U_T	U_B	U_V
17.03	635	459	754
26.03	645	464	769
08.04	670	469	785

Table 9. Bedrock deformations of the gallery.

Deformation speed registered in interval	V_T	V_B	V_V
1	0.9	0.61	0.81
2	2.77	0.11	2.44

During the elaboration of the measurements, this gallery presented deformations all over its length, the bedrock of the gallery reached a total deformation value of 0.785 meters. The speed deformation is in this case between 0.11 - 2.22 mm/day, figure 3.

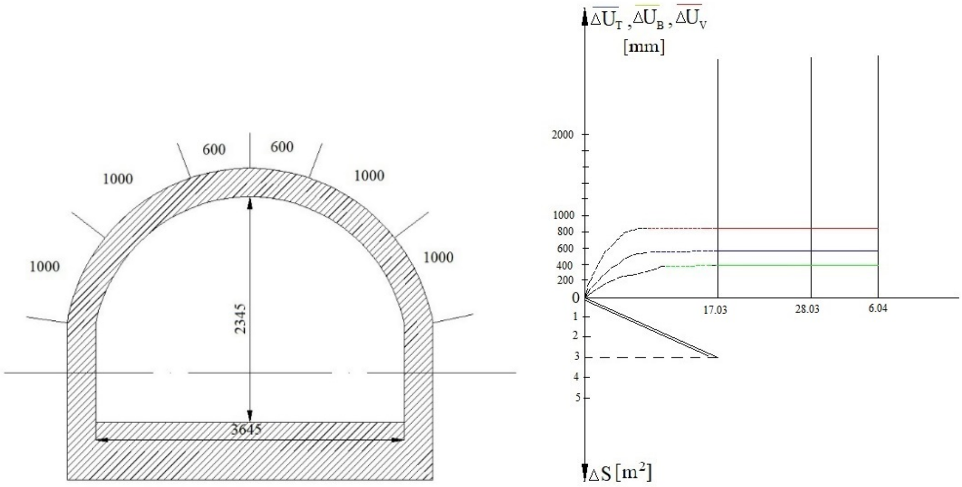

Fig. 3. Main transversal gallery deformation diagram and convergence: a) deformation diagram, b) the convergence graph.

6 The constructive solution

According to Panet-Sulem rock-support interaction system, the main principle of interaction method consists of the following: taking into consideration the tridimensional geometry of a tunnel with the work front, the method introduces the role of the rock (terrain) on the self-support of the work [11]. The idea is that the supported pressure of the support to insure the pit equilibrium, results from the terrain interaction and the support itself, the latter being unable to sustain the weight of a constant load, but a decreasing pressure which decreases as the terrain mobilizes its own resistance, which evidently requires that it (the terrain) should deform [12]. The concept of this evolution, consists in the fact that the role of the support is not to systematically oppose the deformation system, but to satisfy the convergence criteria, based on the traversed rocks, the role of the work, and to optimize the type of support which must be installed, and also the corresponding costs [13].

Taking into consideration the necessity of the used metallic profiles to take the rock pressure as uniformly as possible, we propose as in figure 4, the lining method, respectively its placement method and its dimensions compared to those of the support, which will be placed between the contact surface between the excavated rock and the utilized metallic structure used on temporary or permanent support, as to the uniform load transmission.

In figure 4, the proposed used material is reinforced rubber which allows molding both on the excavated rock contour, and on the whole surface of the metallic profiles, which must work at their constructive performance, the rock-support interaction being realized optimally.

Today, in the mining industry the used linings are made of rectangular wooden plates, as in figure 4.

Fig. 4. Contemporary lining example.

As we can see, the lining-support constructive system presented in figure 3, is not proper for the creation of an optimal rock-support system. To reduce the speed of deformation of metallic structures, we propose using another type of lining, other than wood, made from a material which will allow the uniform transmission of loads as in figure 5 [11-13].

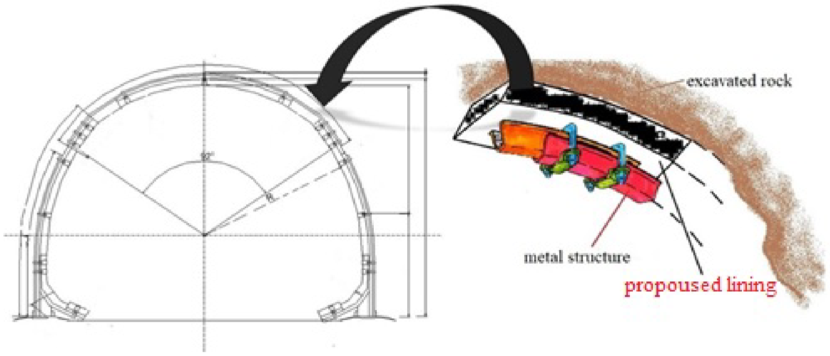

Fig. 5. Proposed lining with visualization and its details.

7 Conclusions

According to what we said at points 3, 4 and 5, both the west and east sides have a pronounced deformation of bedrocks and walls, in some areas, the access alongside the gallery being very difficult. During the study, on the western side, we recorded the biggest deformation speeds, with values between 7.45 – 16.11 mm/day. The wall deformations reached 0.9 – 1.1 meters and in the bedrock 0.355 – 0.636 meters.

The deformation method of the gallery contour inside bedrock layer 3, western side, is random. So, in the interaction zone with the main transversal gallery, the deformations are minimal, but as we get farther from the transversal, and closer to the extraction zone, the deformations reach 0.315 – 0. 61 meters. Alongside the work way, the bedrock is fractured, the pillars of the metallic structure are pushed inside the profile, and those near the layer 3 are deformed. At the date of measurements, the galleries underwent reshaping works, and on a distance of approximately 12 meters, a two pillars experimental support was installed, as in figure 4. Although they are placed at a greater distance inside layer 3 bedrock, the recorded deformation speeds have values between 2.7 – 5.6 mm/day.

The optimization of the lining-metallic structure support constructive system, consists of utilizing a material which is adaptable to load transmission conditions, from the excavated contour to the metallic structure support, respectively the geometric shape and metallic profiles chosen for load receiving from the rock. The uniform distribution of loads and metallic structure distribution is necessary. From a constructive point of view, it is known that in the case of laboratory tests, the experimental metallic structure, improved with two rows of pillars, and joint tightening momentum fixed at 30 daNm, we can observe an increase in deformation speed, starting with the application of bedrock and lateral walls concentrated load, with a pressure of 40 atm on the bedrock, and 35 atm on the lateral walls. The first slidings of the joints of the metallic structure, were present on the uniform transmitted load, on the whole support metallic structure, with the value of 10 atm, and 3 t/frame values.

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