PARTICULARITY AND EFFICIECY OF ROCKS' CONSOLIDATION THROUGH ANCHORING IN UNDERGROUND EXCAVATION SUPPORTING

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Abstract: As an objective necessity of restriction the scope of the steel timbering used for the current metal support of the underground excavations, resulting from the not correlation of the symmetric construction supporting system with uneven maximum vector manifestation of pressure, as well as economic considerations, generated by the high costs and labor for the lamination of metal profiles, by applying to the supplier a additional treatments improve, it becomes increasingly necessary to introduce and generalization on how to consolidate rocks by anchored support. The paper analyzes the possibility of generalization the anchored support for underground excavations, as well as the specific features of this support system in its interaction with the surrounding rock, with the aim of making the option for choosing this method of consolidation the rocks.

Key word: Underground excavation, traction tension, expansion bond, rock massif, support interaction

1. INTRODUCTION

Reviewed in the light of the reliability and safety criteria, theoretical and experimental research performed in recent years shows that the difficult location for underground excavations conditions, steel timbering is requested very irregular and with high intensities of requests. As a result, they lose the lift after a relatively short time from assemblage, because of the local tensions that are formed in certain points of the outline of the work, often in excess of the threshold of the cast flow of execution. In this case, it is confirmed that the deformation is caused not only by the rock massif, but especially of the disparity in support system construction used in relation to the direction of the vector which has a maximum pressure. It is known that the classic metal support with an ordinary operating elastic-sliding system by its construction can take only vertical loads generated by vertical pressure from the ceiling, for limited convergence of rock mass of 150-200 mm. In the case of lateral pressure intensity when the ratio Px/Py > 1, metallic pillars support gives way, due to their limited carrying capacity and opposite reaction at the request of the rock massif with all the adverse consequences for the optimal functioning of support. Therefore, in the current economic crisis situation, when steel mills shall restrict the activity for rolled sections, in order to ensure the stability of the underground excavations, worldwide operations are towards reclaimed for introduction and generalization on anchored support to consolidate rocks, which is getting more and more deeply embraced by the practice of underground construction in our country.

2. ASSESSMENT OF THE FORCE EFFECT OF THE UNDERGROUND EXCAVATION'S SURROUNDING ROCKS

As the outcome of theoretical and experimental research on the mechanical processes can show, the most intense movements of surrounding rocks of underground excavations are produced after the operation of excavation and the advancing front.

The rocks that have a high mechanical resistance are able to ensure a new balance, based on their ability, of self carrying support, instead the rocks with medium and low resistance, such as sedimentary rocks, is suffering from an active process of movement, which is completed by distorting the whole profile of excavation (Figure 1) and as a result it must be supported.

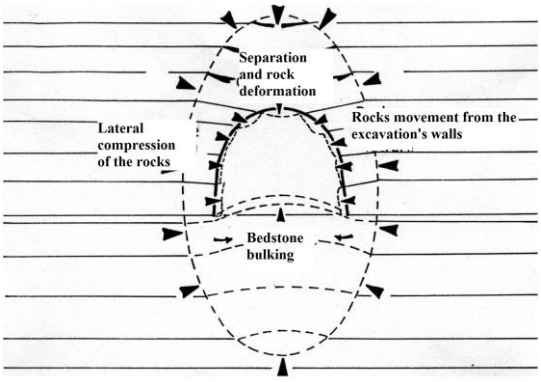

Fig.1 The force effect on the rocks about the underground excavations

The ordinary classical support of metal sliding, having the construction and symmetric arrangement of the elements which compose it, is designed to get the maximum requests mainly in acting on the ceiling of the excavations and, accordingly, through asymmetric redistribution of tension on the contour of the work, the current system of support is no longer match the data [1], [2] [4] [5].

In this case, asymmetric manifestation of ground pressure, when the side requests (Pp1, Pp2) over the excavation, record a superior values to those vertical (Pt), it can appear deformation of the pillars, with loss of balance in the system of "rock-support" and lessening work stability (Figure 2).

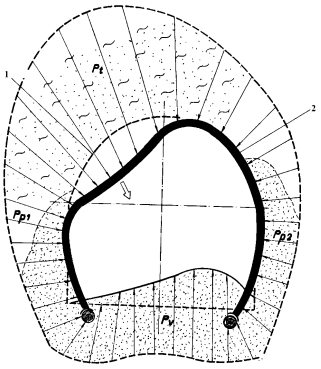

Fig.2. Non-uniform deformation mode of mining works performed with steel timbering, in the case of taking-over the maximum force from the wall located in front of the layer: 1- initial profile; 2- outcome profile after force stabilization

As a result of the less correlation of current construction of classical support with the direction of the vector of maximum pressure, theoretical and experimental research on the mechanical processes have highlighted the need to make maximum use of carrying capacity of rocks, by strengthening their requests with the help of anchored support. In this way it is possible to increase the resistance of rocks against shear and traction applications, with training and involvement of the consolidated area at very short notice, to get the pressure. Such a mechanism of interaction in the "rock-anchor" system is accepted by most experts in the field, constituting the main argument for expanding the anchored support in the most diverse types of rocks.

In this context, in most countries with experience in this area it is diversifying and expanding the anchor rock system, regarded as one of the most important developments in technique and support technology of mining works in the post-war period. The growing interest of the mining industry in Western Europe, USA, Australia, South Africa and others to steel timbering it appears based primarily on the economic situations of the mines and of the efforts made to streamline the work of extraction of useful minerals.

For example the interest in the field of contention that is highlighted, in England, the year 2005 marked a event, this type of support is used for execution of a volume of over 240 km of underground excavations, representing 78% of the total system of opening network and readiness for coal mining, contributing effectively to reduce operating expenses by 2.5 times compared to the original situation. Also, in the past 10 years, the coal sector in the US has consumed annually 100 million anchors of various constructive prototypes and in South Africa, over 65% of the mining underground excavations are supported with anchors based on the principle of friction with the surrounding rock.

3. CHARACTERISTICS OF ANCHOR SUPPORT AND INTERACTION WITH SURROUNDING ROCK

The option to place the anchored support is exemplified by the following features, namely, [3] [4]:

a) reinforce the rock, forming a high carrying capacity pillar which is involved in taking the pressure (Figure 3);

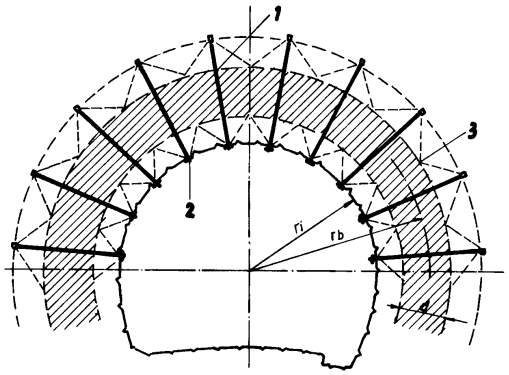

Fig. 3 Formation of consolidation rock pillar: 1- metal anchor (anchor rod); 2 - plate tensioners; 3 - pillar of consolidated rock; d - thickness of consolidated pillar

b) develop forces in various points on the excavation contour, which generate by their action the strains redistribution and limit the deformation of rocks (Figure 4);

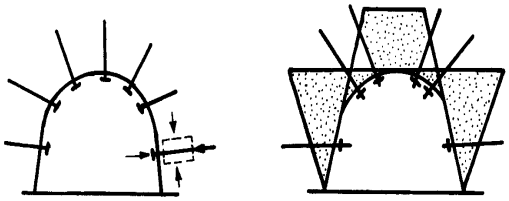

Fig. 4 Influence of anchored support to the development of more consolidation forces on the excavation contour

c) creates an reinforced arch that amplifies the rocks strength and ensure their stability under the conditions of high tensile stresses that develop in excavation's walls (Figure 5).

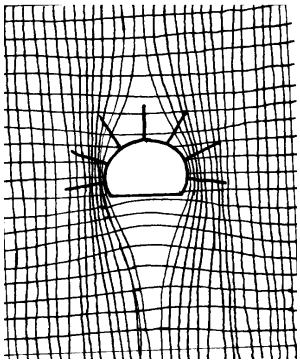

Fig. 5 Redistribution and centralization of tensions into the walls of the mining work

The basic principle in the location and operation of anchors must represent the knowledge of where are located the maximum bending moments, which accounted for 90% of all the main tensions. In this case, if the current metal timbering take the biggest tasks only from the ceiling of the mining work, then the maximum bending moments shall form corresponding the draught in Figure 6.

Therefore, the area of maximum moments of action A and (B) shows the most intense movements and deformations of rocks, where it becomes rational placement of anchors in these areas and in the ceiling and walls. Mounting anchors into the wall provides not only the deformations reduction and but the maximum bending moments reduction, too, which manifests itself in the pillars of the contention, but also fosters the formation and development of additional internal forces that improve the interaction in "rock-support", participating in the growth and stability of mining work.

On the other hand, experimental researches carried out in situ confirmed that the assemblage of anchors only in the side walls of the mining work, where take place the greatest movements and deformations of rocks, achieves a more even distribution of tension across the outline and also reducing traction efforts. As a result, in the situation when the movement of the wall rocks predominate, with the development of lateral pressures (Figure 6 c), anchors must be installed in the point C (Figure 6 d). If the adits located under the influence of

jackhammers, exhibited asymmetric at the force of of maximum pressure vector (Figure 6, e), the draught of maximum bending moments indicates the correct placement of the anchors to the points D and E (Figure 6, f) so that the effectiveness of the stabilization action to be maximum achieved, with a reduced consumption of materials.

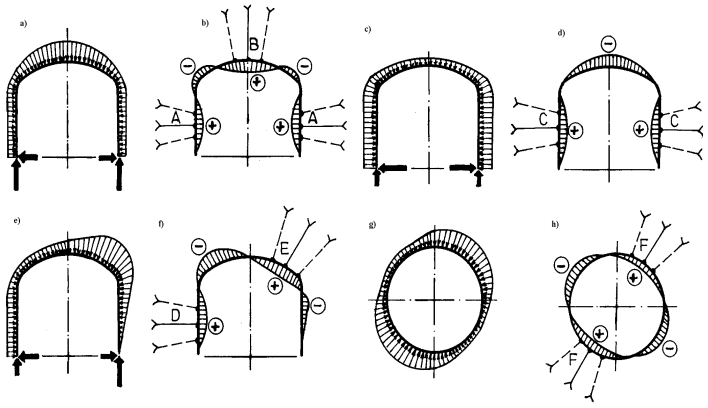

Fig. 6 The areas of maximum bending moments surrounding the underground excavations for different types of profiles and forces: a, b – the case of arch profile and maximum forces from the ceiling; c, d – the case of arch profile and maximum forces from the walls; e, f – the case of arch profile and maximum asymmetrical forces from the ceiling; g, h – the case of circular profile and maximum vertical forces (ceiling and floor)

For circular profiles of mining works, which also supports asymmetric stresses of pressure (fig. 6 g) is the rational the location of the anchors at the point F (Figure 6 h), i.e. in those sectors of the work's outline where the trend of deformation of rocks records the maximum value.

d) compared to traditional support, the consolidation of rocks using the anchors provides a more effective balance in the system of "rock-support" which can be explained by the consolidation pillar and engaging the anchored support in taking over the pressure shortly after the installation
(Figure 7).

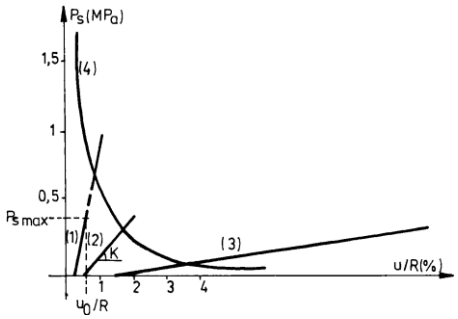

Fig.7 The role of consolidation in the interaction of "support – rock": Uo - rock deformation of around the underground excavation; R - radius of the mining work

Based on the presented graphic, reveals that for average values of 0.4 MPa (40 t/m^2, the work characteristic of rigid support of concrete and arch keystone (curve 1) indicates that this type of support get the total deformations, their characteristic curve having failed to intersect the curve of deformation of rocks (curve 4) surrounding the underground excavation.

In the case of anchored support (curve 2) is made the consolidation pillar of rock with much higher carrying capacity and with a nearly identical feature (curve 1) but, due to the larger amount of lift that is developing, ensures the balance of rock massif.

In the case of elastic support from metal sliding support, the characteristic curve (curve 3) intersects the relax curve of rock after a long period of time, but for larger deformations of rocks or repeated elements sliding and smaller amounts of forces, in which case the balance with the rock support and stability of mining work occurs for large reductions of profile excavation not being met in full the conditions of efficiency.

4. CONCLUSIONS

Options for choosing an appropriate support according to the diverse manifestation of tasks around the underground excavations, in addition to the need for the allocation of expenditure and labour consumption as low as possible, will have to consider and use of carrying capacity of the surrounding rocks, made possible by enhancing them with the help of anchored support. According to the constructive and working particularities of such support, as stages in the underground application, it is imposed the holes boring radial on the excavation contour, followed by implantation of anchor rods and setting the pre-stressing plates, immediately following the unveiling of the rocks, with the rows spaced on layout direction of the work depending on the type of intercepted rock and type of anchorage used.

For difficult geomechanical conditions, the anchored support may be associated with concrete support, with the aim of rocks protecting against the alteration, which is designed in 2-3 successive layers with thickness of 2 to 5 cm over the metal mesh for bandaging.

REFERENCES

[1] Pleşea, V, Vlaicu Popa, M.E., Vlasin Nicolae-Ioan – *Elemente de proiectare a susţinerii modulare din armături metalice în asociere cu procedeul de consolidare a rocilor prin ancorare.* Analele Universităţii „Constantin Brâncuşi" Târgu Jiu, Seria Inginerie, Nr.4/2012;

[2] Pleşea, V., Manolea, Gh., Ghinia, S., Radu, S., Stochiţoiu, D., Vlaicu Popa, M.E.-*Advanced prediction procedure for the underground stress manifested în the undermined coal bed works.* Wseas Transactions on Advances în Engineering Education, ISSN 1790 – 1979, Issue 6, vol. 7, June 2010, pp. 192 – 2001;

[3] Pleşea, V. - *Constructive and functioning improvement solution of the sliding steel timbering for underground stability* **.** Annals of the University of Petroşani. Mining Engineering vol. 10 (XXXVII), ISSN 1454 – 9174, 2009, pp. 101 – 106.

[4] Pleşea, V. – *Proiectarea şi construcţia susţinerii lucrărilor miniere subterane din sectorul carbonifer.* Editura UNIVERSITAS, Petroşani, 2004;

[5] Pleşea, V., Butulescu, V. - *Răşini poliuretanice folosite în construcţiile miniere de la suprafaţă şi din subteran* . Revista Minelor, nr. 2, 2003, pp. 35– 39;