THE CORRELATION BETWEEN UNDERGROUND ROCK EXCAVATION PARAMETERS AND THE DESIGN OF PROPER SUPPORTS

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ABSTRACT: Theoretic and experimental research of the mechanical processes occurring during the execution of underground excavations reveal that the installation of the roof support intends to stop the migration of rocks to fill the void created, by creating and involving the ‘rock-support’ system, shortly after having been executed, in taking over the load. Particularly expressing its specific operation, the interaction mechanism of the support-rock system, accepted by most of the specialists in the field, needs to be correctly explained and assessed, constituting the main argument in forecasting the parameters and the opportunity to use adequate supports considering various conditions and type of rocks. Using and designing therefore the supports depends on a series of factors, some of which, the paper brings forward, analysing their influence on the underground excavation parameters, namely the influence of the digging technology.

KEY WORDS: design, excavation parameters, stability, support, underground mining

1. INTRODUCTION

One of the most important conditions for an efficient mining activity is constituted by the stability of the mining work and maintaining their full state of operation during the service, with minimal maintenance costs.

The stability problem of mine works has become rather complex lately due to the extension of the excavation depth which is continually increasing, the aggravation of the geological conditions, the appearance of a series of difficulties in controlling the mine pressure as well as the increase of material and maintenance costs. Therefore, the methodical approach of the methods to improve the parameters of the types of supports and to design new constructions in order to carry out underground mining works needs to be first based on a good knowledge of the working conditions which allow an assessment of the interdependence between the forms of mine pressure, the stability of the massive rock and the parameters of the support.

From the series of factors which take part in endangering the balance of the rocks with the support and consequently functionally modify their interaction mechanisms, by affecting the stability and the integrity of the underground mine works, the paper deals as follows with the influence of the execution parameters of such execution works, namely the influence of the digging technology.

2. THE ADEQUATE DESIGN SUPPORT INFLUENCE ON THE STABILITY OF THE DIGGING TECHNOLOGY IN UNDERGROUND COAL MINE

The influence the digging method has on the stability of the mine work and on the choice of adequate supports is manifested through structural-textural changes of the rocks occurring on the mine outline, generating therefore the appearance of technological fissures, which in their turn determine the change of the characteristics of the rocks, in the sense that they reduce their value as well

as their volume through the amplification of the coefficient of expansion.
The structural-textural changes of rocks, which lead to the occurrence of unfavourable consequences on the deformation and the manifestation of the secondary status of stress on the outline of the horizontal mining excavation, are presented in Figure 1.
The geomechanical assessment of the influence of the digging method on the stability – reliability of the horizontal mining work is dealt with in Table 1.
The influence and the deficiencies the digging technology has on the stability of the works and consequently on the interaction mechanism are enhanced as well by the irregularities which occur on the outline of the mine work, determining therefore more acute stress build-up than in the case of a smooth outline [2],[3],[4].
Taking into account the value of the parameter RQD, which deals with the quality of the massive rock, it is recommended that the following type of supports be used (Table 2).

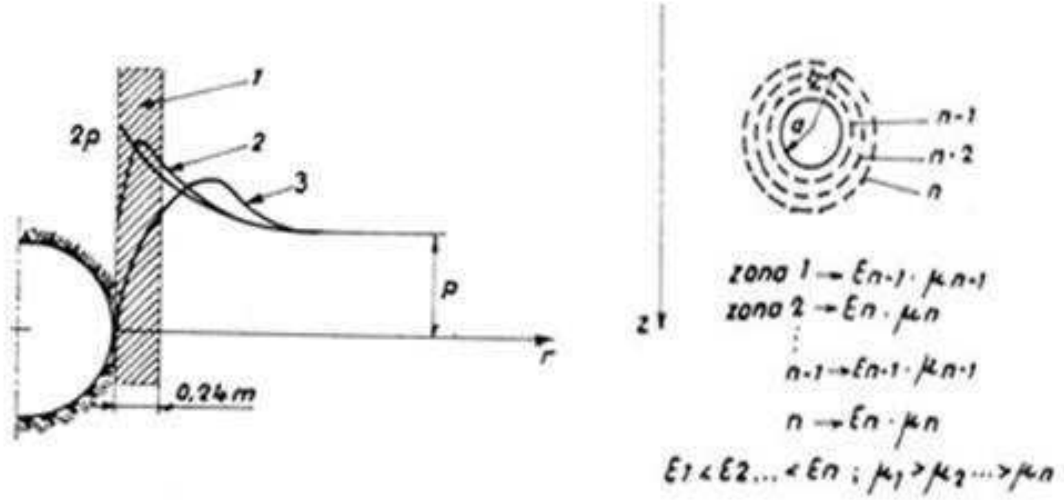

Figure 1. The influence of the digging technology on the secondary status of stress – strain of rocks: **a**-modifying the status of stress – strain of rocks; **b**-the variation of the deformation module of the rocks surrounding the mine work;**1**-measured area;**2**-area created using the cutting-loading machine; **3**-area created using classic drilling-blasting procedures

Table 1. The influence the digging method has on the stability – reliability of the mine work

Scenario	Geomining conditions-stability index - i_s	Characteristics of the rocks deformation behaviour occurring on the outline of the mine work	Recommended digging method
I.	The scenario where the geo-mining conditions satisfy the following inequality: $\sigma_i < \sigma_{lld}$ $i_s < 0.5$ or $i_s < 0.35$	Independent on the digging method, the movement of the opening is determined by elastic and creep deformations of rocks. The opening is situated within stability limits, the technologic fissures does not travel into the massive and only reduced, local rock detachments may appear..	The cutting-loading machine has more advantages as the technologic fissures created through drilling and blasting decrease the value of the module of deformation of rocks and therefore the deformations of the outline of the work reach values 1.5 ÷ 2 than if a cutting loading machine were used.
II.	The scenario where the geo-mining	Independent on the used digging method, the status of the mine work is stable, considering that	In these conditions, the use of the cutting-loading machine for digging expands the field of geo-mechanical

	conditions favour the occurrence of a secondary active status of stress: $\sigma_i > \sigma_{lld}$	when stress σ_i exceed insignificantly σ_{lld} through drilling-blasting, the status of the work worsens and the delimitation between the two states, i.e. stable-unstable is considered therefore $i_s \leq 0.3$, while using the cutting-loading machine the technologic fissure is absent and the deformation process is not accompanied by intensive expansion. The movement is slower and more reduced, moving from stability to instability happening for $i_s \leq 0,35 \div 0,40$.	and technologic conditions for which the work will be found within the limits of a stable status.
III.	The scenario in which: $\sigma_i > \sigma_{rcM}$ and $i_s > 0,5$	The rocks will chip away independent on the used digging method. The relaxation and movement of a large amount of rock is favoured before installing the support. The movement is the result of elastic-viscous-plastic deformation of the massive and of the expansion phenomenon occurred in the area of the intensive fissure.	The use of cutting-loading machines produces a slowly occurring deformation process, so the non-elastic deformation area is created a longer time than when using the drilling-blasting digging procedure. Therefore, in the case taken into account, the drilling-blasting procedure may be more favourable than the mechanised one, the movement of the mass of supported rock will be reduced.

Table 2. Recommended type of supports and digging procedures for the works considering the parameter RQD

Massive Rock Quality	**Digging Method**	**Metallic Arcs (L-armouring field)**	**Anchors (a-Distance between anchors)**	**Grout (d_o-grout thickness)**
1	2	3	4	5
Excellent RQD > 90	A. Mechanized B. Drilling-blasting	SG 18, occasional SG 18, occasional	Occasional Occasional	Locally Locally; d_o=5÷cm
Good 75<RQD<90	A. Mechanized B. Drilling-blasting	SG 18, L=1.5÷1.8m SG 18, L=1.5÷1.8m	a=1.2÷1.8m a=1.5÷1.8m	d_o=5÷7cm d_o=5÷7cm
Approximately good (medium quality) 50<RQD<75	A. Mechanized B. Drilling-blasting	SG 23, L=1.5÷1.8m SG 23, L=1.5÷1.8m	a=1.2÷1.8m a=0.9÷1.5m	d_o=5÷10cm d_o=10cm

Weak 25<RQD<50	A. Mechanized B. Drilling-blasting	SG 23; L=0.9÷1.2m SG 23;SG 29; L=0.6÷1.2m	a=0.9÷1.5m a=0.6÷1.2m	d_o=10÷15cm d_o=15cm
Very weak RQD<25 (rock without any expanding properties)	A. Mechanized B. Drilling-blasting	SG 23; SG 29 L=0.6m SG 29; L=0.6m	a=0.6÷1.2m a=0.9m	do=15cm do=15cm
Very weak RQD<25 (rock with expanding properties)	A. Mechanized B. Drilling-blasting	SG 29 - circular; L=0.6m SG 29 – circular; L=0.6m	a=0.6÷0.9m a=0.6÷0.9m	d_o=15cm d_o=15cm

Based on the analysis of the existent conditions in Jiu Valley, carried out on collected blocks of rocks it results that the values of parameter RQD are more increased in the western part of the basin, i.e. 54.73%, reduced in the central part of the basin, i.e. 39.57% respectively 22% in the eastern part. It may therefore be stated that there is a relatively increased stability of the rocks in the western part of the basin, namely 50 < RQD < 75, for which the recommendation would be the use of combine supports formed of metallic arcs installed in extended fields (over 1m) and anchors, the distance between the lines being 1.2 ÷ 1.4m, or an anchored support and grout with a thickness of 10 ÷ 15cm [1],[3],[4]. For the perimeters of the central and eastern parts, the analysed rock is comprised in the category of weak rocks (25 < RQD < 50), which require the application of supports formed of average weight laminated sliding metallic arcs, such as SG 23, respectively SG 29, installed in reduced fields, namely 0.5m and 0.7m, associated with anchors installed at a distance of 0.8 ÷ 0.9m, reinforced with grout, applied with a minimum thickness of 15cm. In case the classic procedure of drilling-blasting technology is used, together with the appearance of a more pronounced degree of fissure of the rocks on the outline of the mine work, it also results irregular outline pattern, having a priority for the incorrect establishment and use of the specific parameters for this digging procedure. The existence of irregularities in the outline of the mine, with the formation of overextensions or thresholds (Figure 2) directly influence the dual operation method "support-rock" through the appearance of contact points between the support and the rock [2],[3]

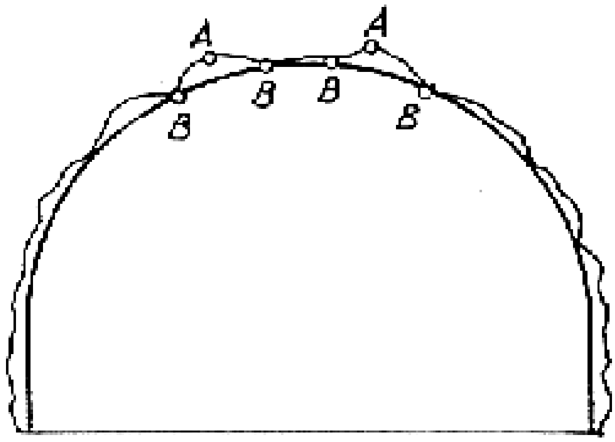

Figure 2. Contact points between the support and the rock on the outline of the mine work

In point A, situated outside the contact with the support, there is an unfavourable status of stress which needs to be taken over only by the surrounding rock. Therefore, the rocks near the mine work are degrading rapidly without putting any load on the support. Concentrated loads are transmitted to the support in support-rock contact point B, which determine the local wear of the support.

In time, the occurrence of stress determines the degradation of the rock and compromises the interaction of the support, even if the value of the stress is smaller than the bearing capacity of the support. It results therefore that the technological digging solutions for the mine work needs to follow the creation of an outline close to the one designed, in order for a continuous contact between the rock and the support to be realised and the two systems (the support and the rock) to operate together as a unit. If the contact between the two systems, along the outline, occurs later, or it is discontinuous, there is a recording of the increase of the deformation and instability phenomena materialized through the movement of the rocks around the underground excavation.

Due to such a contact, i.e. insufficient or random at the interaction between the support and surrounding rock, the construction of the actual metallic support fulfils in real terms only the function of an enclosure and not its real supporting function. Moreover, the irregularities of teh outline of the work and the randomness of contact points support-rock, condition the creation of stress spots with an increased value and different from a smooth outline obtained during the use of a cutter-loader machine.

3. CONCLUSIONS

Obtaining a profile with the elimination of the irregularities is of great importance and consists of the modality in which the load is supported, which in the case of drilling-blasting is sent concentrated, only in the contact points of the massive rock with the support. In which case the increase of the number of frames per meter of work, in the case of metallic props, or the use of rigid masonry supports made of cinder blocks or prefabricated materials, does not influence the deformation value of the massive and does not ensure a corresponding increase of the stability oF the mine work. Moreover, the behaviour in time of the load leads finally to the wear of the rock as well as of the support, in which case in order to rebuild the rigid supports, additional costs and manpower are required as well as costs related to materials and maintenance.

Consequently, the classic digging procedure, namely drilling-blasting, implies the optimisation of the parameters which determine the smooth outline of the mine work as close as possible to the designed one. Therewith, the constructive solution of the support shall follow its appropriate adherence to the rock in order for the system support – rock functions as a whole and not dependent on one another. Therefore, in this a context an improvement of the operating conditions of the support may be reached, ensuring as well its operational safety and increasing the stability – reliability of mine works and the interaction of the rock – support system.

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