PROCEDURES AND EQUIPMENT FOR DRILLING HOLES FOR THE INSTALLATION OF ANCHORS FOR THE SUPPORT OF UNDERGROUND MINES EXCAVATIONS

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ABSTRACT: considered an integrating part of the new modular support, the anchored support for the consolidation of rocks, associated with the basic sliding metallic shield support, implies the drilling of holes and installation of anchors in the massif rock according to diagrams and designing principles appointed considering the geo-mechanical conditions of the rocks met while carrying out the underground excavations. The researches carried out up to the present in the field of anchor installation have highlighted that the technical and economic performance criteria for the execution and durability of underground works, namely mine opening works and works carried out for the preparation of the mineral oar, are judiciously carried out if the drilling of holes for the insertion of anchoring rods is given its rightful importance in order to correspondingly chose the equipment required for the execution as well as for a competitive use of anchors.In order to ensure the competitive characteristic of the reinforcement procedure of rocks using anchors for the execution of underground mine excavations, the paper deals with some of the most performant drilling solutions which suppose the use of installations capable of contributing to the full mechanisation of the drilling process and the installation of rigid or flexible metallic rods.
KEY WORDS: undergr*ound excavation, massif rock, anchored support, anchors' drilling and mounting* installation, anchorage holes, holes anchorage materials.
Insert keywords .

1. INTRODUCTION

The analysis carried out during the experimental phase of the project showed that from the total time necessary for the installation of an anchor 80% is spent for drilling. On an international scale, a series of companies which are experienced in the field of anchors' installation have already begun to design and install modern drilling machineries, capable of fully automating the entire drilling and anchored supports mounting process in a relatively reduced amount of time which does not exceed 40 ÷ 50 seconds. In most of the foreign speciality publications the drilling installations are classified in three main groups [1],[2]:
A – Manual installations, comprising by light and medium drilling machines considering their weight, installed on PR8 type telescopic columns, respectively on

P-90 ones and simple equipment used for mounting the anchors;
B – Semi-mechanised installations which ensure automatic drilling and use manual equipment for the installation of anchors;
C – Fully mechanised installations, capable of realising the mechanised drilling and anchors' installation, the control being carried out by a platform placed in the supported area of the work for the protection of the installer.

2. DRILLING AND ANCHORS' MOUNTING INSTALLATIONS

A. Manual installations. Are recommended for mine works of reduced dimensions, carried out with manually controlled installations. Anchoring holes may be realised with the same equipment used for the classic mining procedure, namely drilling-blasting, while the installation of the rods is made manually (figure 1, A).

The carts from the coal face may be also used as platforms, both for drilling the ceiling of the mine work as well as for the installation of anchors. Pneumatic operated rotary perforators were therefore designed and manufactured for the coal sector, namely the PR8 ones which are also recommended for breaking the resin cement vials in the case of complete binder mounting of the anchored support.

B. Semi-mechanised installations. They are being used in large mine works as well as tunnels, where the telescopic columns on which the manual drilling machines are installed are not able to ensure the normal operation of the drilling process. It is therefore appreciated that perforating trolleys are far more appropriate for drilling the anchoring holes (Figure 1, B.1.) Sometimes, the mentioned trolleys are fitted with an operating arm of specially designed working platforms which allow the installation of anchors on the ceiling of the mine work (Figure 1, B.2). Afterwards, the installation of hydraulically operated perforators on the arm of digging machineries, was experimented, in order to render mechanised drilling of the ceiling of the mine work easier (Figure 1, B.3).

Considering small cramped spaces, specific for GDM-10 and GDM-11 mine works of Jiu Valley, where the length of the arm in the console of the perforating trolley cannot be adapted to the dimensions of the dug section of the work, telescopic columns found in the mines may be me used [2],[3].

C. Fully mechanised installations. The installations used for the full mechanisation of the anchoring process allow mechanised drilling of anchoring holes and mounting of anchors. The installations mentioned within the paper are controlled from a command cabin, where the miner carries out all the necessary manoeuvres. Figure 2, C.1 and C.2. deal with two installations used for full mechanisation of the anchoring process, designed by ATLAS COPCO. The installation presented in Figure 2, C.1 is recommended for a full mechanisation of the operations in order to install Swellex anchors. The installation in Figure 2, C.2 is fitted with an advance system with three mounting positions of the perforator. These installations were designed therefore for the mechanised implantation of the supports completely fixed in mortar, synthetic resin vials or Split Set and Swellex anchors.

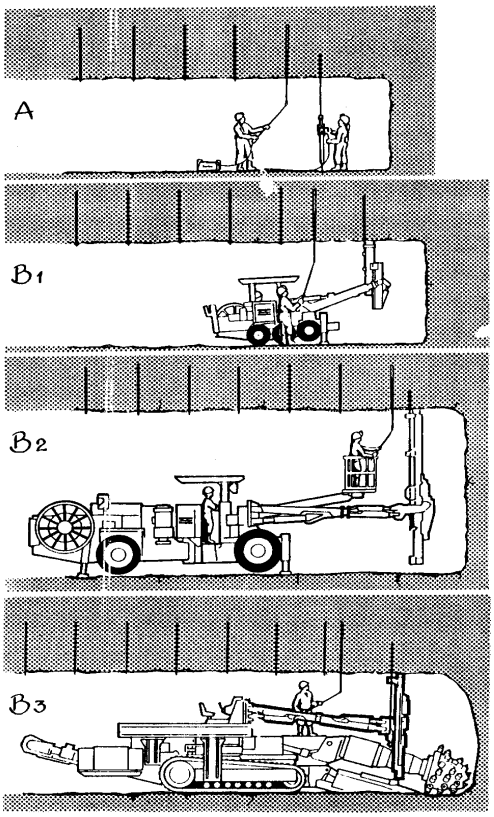

Figure 1. Anchors' implantation equipment in the massif rock: **A**- manual anchoring with light perforators installed on telescopic columns; **B.1**.- Semi-mechanised anchoring using reduced sizes perforating trolleys and manual installation of the anchored supports; **B.2**.- Semi-mechanised anchoring using large dimensions trolleys for manual installation of the supports; **B.3**.- Semi-mechanised anchoring using advance combination machineries foreseen with hydraulic perforators for manual installation of the anchors.

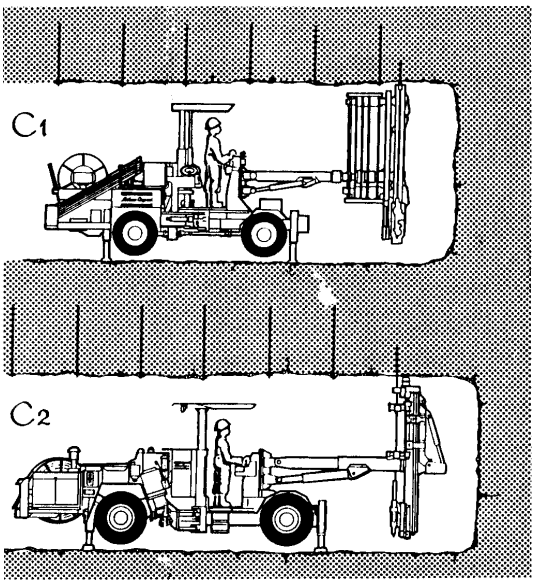

Figure 2. Installations used for fully mechanised mounting of anchors: $\mathbf{C_1}$-Installation for mounting Swellex anchors; $\mathbf{C_2}$-Installation for mounting different types of anchors.

Although it is difficult to justify the large costs for the use of complex installations to ensure the full mechanisation of the perforation and installation of anchors, this solution of the process shall be extended in the future for the following considerations:

- Miner's safety is highly improved and increased. While carrying out all the technological anchoring operations the miner, namely the operator, is at a considerable distance from the place where anchors are installed, where the ceiling of the work has already been supported. Moreover, it is protected in the case of rocks' displacements;
- The harmful effect of cement of resin particles liberated during injection is avoided;
- Avoiding allergies caused by the chemical effect of resins;
- The malfunctions of the perforating equipment are minimum;
- Every anchor is immediately installed after the perforation of the wholes, the risk of rock displacement being reduced to a minimum;
- All the technological operations are carried out by only one miner.

Considering all the aforementioned facts, specialised companies such as Atlas Copco, Secoma, Titanit and other, manufacture complex installations for full perforation and installation of anchors. As an example, Figure 3 presents the installation manufactured by the French company Titanit.

The coal industry in Germany and England has carried out experiments for the past few years obtaining very good results and advance combination machines which can be used for the anchorage operations. The digging and anchorage support speed in these cases is comprised between 12.2 to 18 m/day.

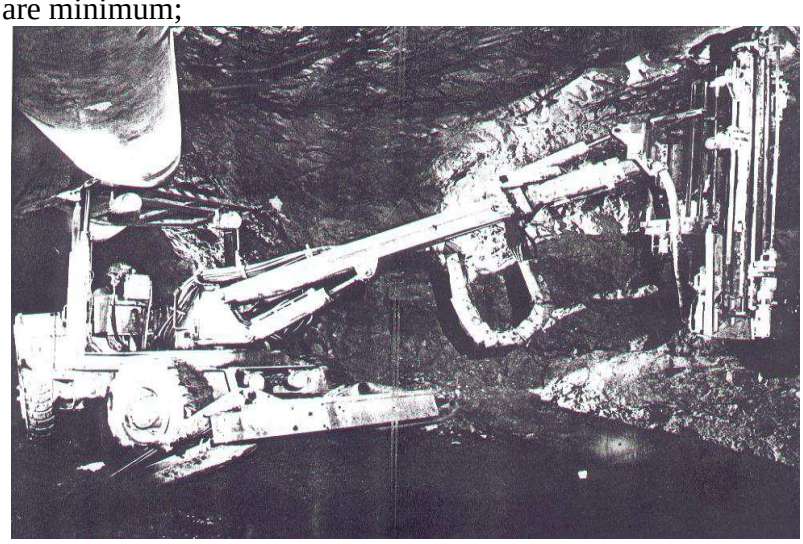

Figure 3 Installations manufactured by Titanit for full mechanisation of the drilling and anchor mounting process

3. TECHNICAL PERFORMANCES ANALYSIS OF DIFFERENT INSTALLATIONS USED WORLDWIDE

The analysis related to the economic situation regarding the equipment used to carry out the works needed to mount the anchors were carried out by Atlas Copco. Two types of anchors completely fixed in cement and Swellex friction anchors. The equipment and the performance for which the comparative analyses were carried out considered the manual, semi-mechanised and fully mechanised equipment. [2].

3.1. Experiment conditions

- Type of rock - granite;
- The length of the hole - 2.5 m;
- The diameter of the hole
  35 ÷ 38 mm;

- The type of anchor Swellex friction fixed.
  Completely fixed in cement

3.2. Experimented equipment and obtained results

The type of equipment analysed and their characteristics are presented in Table 1.

Table 1

Type of installation	Diameter of the hole	Perforating speed	Average value
Manual perforator BBD 90	35 mm	0.35 – 0.50 m/min	0.43 m/min
Semi-mechanised Perforator COP 1032 HD	38 mm	0.85 – 1.40 m/min	1.10 /min
Full mechanisation Perforator COP 1032 HD	38 mm	0.85 – 1.40 m/min	1.10 m/min
COP 1028 HD	38 mm	0.65 – 1.15 m/min	0.90 m/min

3.3 Operational anchorage times (minutes) realised by a miner using different experimental equipment (Table 2)

Table 2

Operation	Manual	Semi-mechanised	Full mechanisation	Semi–mechanised	Full mechanisation
	Cement fixing anchors			Swellex	Swellex
1	2	3	4	5	6
Hole drilling	5.80	2.30	2.30	2.80	2.80
Return race of the drill	0.40	0.20	0.20	0.20	0.20
Cement coupling	0.50	0.50	0.05	-	-
Loading the hose	0.40	0.40	-	-	-
Cementing	0.40	0.40	0.05	-	-
Anchors' connection	0.50	0.50	0.05	0.50	0.05
Anchorage	0.50	0.50	0.35	0.50	0.35
Positioning for the following hole	1.50	1.00	1.00	1.00	1.00
Effective anchorage time	**10.05**	**5.85**	**4.00**	**5.00**	**3.40**

Based on the results obtained it is observed, as it was expected, the reduction of the total time of implantation of the anchors considering the level of mechanisation of the operations. Therefore, if the rods are fixed with cement, there is a reduction of the times with 42% compared to manual anchorage when it is carried out in a semi-mechanised way, respectively with 60% when anchorage is made in a fully mechanised way compared to the manual anchorage and 31% in the case of full mechanised anchorage. If the rods are fixed through friction (Swellex anchors), the reduction is maintained considering the level of mechanisation of the procedures, including this procedure, which does not use any additional anchorage material of the rods in mine holes, compared to the one using cementation, respectively 15% reduction when anchorage is carried out in a semi-mechanised or a fully mechanised way.

4. APPRECIATION REGARDING THE OPERATION OF INSTALLATIONS USED FOR MOUNTING ANCHORS [1], [2], [3]

Complex installations ensuring full mechanisation of the drilling and mounting of anchors have proven their technical performances acknowledged internationally. Although, their applicability percentage in the mining sector in our country continues being limited and does not exceed 10% due to the weight of the machineries and increased purchase cost. Considering the previous mentioned facts, a series of specialised companies in the field of anchorage, such as Rock Mechanics Technology Ltd from Anglia and CarboTech from the Czech Republic, use manual drilling installations installed on telescopic columns simply manufactured, capable to develop, in the frequently met rock, drilling speeds of 1.0 ÷ 1.5 m/min. They have a proven increased manoeuvrability being adaptable in the case of mining profiles GDM-10, GDM-11, GDM-14, frequently used in Jiu Valley minessuch a simple installation was experimented in Paroşeni mine as well as in Petrila Mine by specialists working for Rock Mechanics Technology, the economic-technical results obtained being appreciated by the technical and engineering staff of the before mentioned mines (Figure 4).

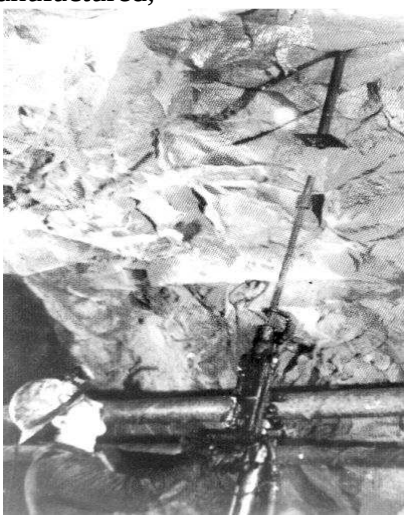

Figure 4 Manual drilling installation fitted with a perforator which can be easily fixed on a telescopic column

It is to be observed that the working methodology for such an installation is similar to the solution presented in Figure 1 A and it is considered that in the actual phase it is more appropriate to use it internally, as the entire anchorage process may be carried out for a more reduced cost compared to the complex drilling-anchorage installations. Moreover, the manual drilling installations may be adapted with good results, if the contact-point advance cutting machines are used, without any type of constructive change.

CONCLUSIONS

In the present phase, considering foreign mines, it is estimated that approximately 50% of the total number of anchorage operations is carried out using individual perforators mounted on telescopic columns. Semi-mechanised anchorage records a 40% percentage of all the activities of anchored supports while 10% goes to the fully mechanised part of this operation.

Based on the experience of countries where mining is developed considering the field of rock anchoring, as well as on the results obtained from the experimental researches carried out in a certin period in Jiu Valley mines, the improvement and extension of the friction Swellex and Split Set rocks' anchorage procedures are proposed, the main operations of which, namely hole drilling and anchors' mounting are made manually using light or medium weight machineries mounted on telescopic columns.

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REFERENCES

1. Plesea, V., Radu, S. M, Veres I., Vlaicu Popa M. E. – Competitive solutions to support underground mining works aligned with the top performance in terms of operation and use of coal for energy production. Annals of "Constantin Brancusi" University of Tg. Jiu, Engineering Series, no. 2, 2015.

2. Pleşea, V. - Design and construction support underground mining works in the coal sector. UNIVERSITAS Publishing House, Petroşani, 2004, ISBN 973 – 8260 – 68 – X, pg. 251

3. Veres, I, Radu, S.M, Ghimisi, S. S., Stăncioiu, A.,Plesea, V., Vlaicu Popa M. E, s.a. - Study and analyze technological project on construction and operation of the current type of support. Phase II of Project no. 51/01.07.2014 contract through the Programme for Partnerships in Priority Areas — PN II, Carried out with the support and help of the Ministry of Education – UEFISCDI, Petrosani, oct. 2015

4. Veres, I, Radu, S.M, Ghimisi, S. S., Stăncioiu, A.,Plesea, V., Vlaicu Popa M. E, s.a. - Study on geomechanical characterization of coal and rock structures and lithological Jiu Valley Oltenia. Phase I of Proiect no. 51/01.07.2014 contract through the Programme for Partnerships in Priority Areas — PN II, Carried out with the support and help of the Ministry of Education – UEFISCDI, Petrosani, 2014