THE CONTOUR BLASTING APLICATION IN THE KOSOVO MOTORWAY PROJECT IN BELLANICA

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ABSTRACT
With the use of contour blasting, we make the cut of the rock at the projected bench's line without damaging the part of the bench that is foreseen to be left as a security site, where the security benches are of great importance in the event of the breakdown of a block or collapse of small stones who are separated from the massif by changing the temperatures, the atmospheric precipitation and ice created by the cold. For to have the good cut of the bench, we must to use the distance between contural drillings approximately 0.75 [m].
Keywords: *Contour blasting, explosive, nonel detonator, nonel connector, drilling.*

Introduction

With the development of technology it is possible to make surface exploitation of minerals even at very large depths at a low cost.

In order to enable the exploitation of various minerals with surface mine method, it is required to work smoothly benches and without cracks, it is also required to work the road with a small incline in order not to be laborious for the transport equipment's.

But in order to make exploitation of the above mentioned method, it is required that the exploitation to be made from up to down and the slopes are safe, durable and without stone dependent, so as not to endanger people and equipment that are involved in the process of mineral exploitation.

Also during road construction in hilly terrain and built with strong rocks, especially during highway construction, it is required to cut the hill to enable the achievement of its projected incline.

During the surface exploitation of minerals and road construction it is also required that the benches and the slope in general be worked on the projected line, not crossing the boundaries, because crossing the boundaries increases the work and increases the cost of mineral exploitation or road construction, because it is required to excavate more sterile material than projected for.

In order to achieve safe and smooth benches without stone, contour blasting's must be used, which make cutting the environment in the projected line.

More extensively, all of the above mentioned, regarding the construction of the benches will be elaborated in the continuation of this paper.

Selection of the explosive

For to make the contural blasting's we must to make the selection of the explosive for production drillings and for contour drillings. It is necessary to do, because we must to make the blasting in combination of them drillings.

Selection of the explosive for production drillings

During the removal of rock masses on the roadway line, the method of massive blasting with deep drilling is applied, while the secondary blasting are not applied for the crushing of blocks because the road construction companies possess a hydraulic hammer for breaking blocks.

The choice of detonation velocity that must have the explosive, is based on equation:

$$D = K_0 \cdot \frac{C \cdot \gamma}{\Delta} \tag{1}$$

$$D = K_0 \cdot \frac{C \cdot \gamma}{\Delta} = (0.63 \div 1) \cdot \frac{1800 \cdot (2.6 \div 2.7)}{1.05} = 2808 \div 4628 \quad \left[\frac{m}{s}\right]$$

D – Detonation velocity of explosive [m/s]

Δ – Density of explosive 1.05 [g/cm³]

γ – Volumetric weight of rock 2.6 ÷ 2.7 [g/cm³]

C – The speed of spreading sound waves in limestone (taken from the literature) is 1800 – 2000 [m/s].

K_0 – The coefficient that has the value (0.63 – 1), it has the bigger value for homogeneous rocks environments.

Taking into account the obtained results which condition the choice of the type of explosive also taking into account the so far successful application of the explosive "ANFOKOS", it is recommended that this type of explosive or explosive with different names depending on manufacturers but having the characteristics close to the same as "ANFOKOS", to be used for blasting jobs on the roadway.

Selection of the explosive for contour drillings

Since the benches on the final contours of the roadway are foreseen to remain durable for a long time, how much the road will be used, then they are required to have high security and not have the stone dependent that later they will have falling of stones

This is achieved by using contour blasting's, where for this kind of blast should be selected explosive material with high detonation speeds and packed in cartridges.

The choice of the detonation velocity that the explosive must have for contural drillings is based on the equation (1):

$$D = K_0 \cdot \frac{C \cdot \gamma}{\Delta} = (0.85 \div 1.2) \cdot \frac{(1800 \div 2000) \cdot (2.6 \div 2.7)}{1 \div 1.27} = 3132 \div 7020 \left[\frac{m}{s}\right]$$

Δ – Density of explosive (1 ÷ 1.27 [g/cm³])

K_0 – The coefficient that has the value (0.63 – 1), it has the bigger value for homogeneous rocks environments. Where from the results obtained from the experience of the contural blasts have been acquired the coefficient values (0.85 ÷ 1.2).

Taking into account the obtained results which determine the choice of the type of explosive, also taking into account the so far successful application of the explosive "EMEX", it is recommended that this type of explosive or explosive material of another name depending on manufacturers but having the same characteristics as the "EMEX", to be used for the work of contural blasting's on the roadside.

Drilling parameters and blasting's material

The rock mass should be drilled and blasted, then postponed and loaded with a digger or an excavator.

Granulation of the material is closely related to the technical parameters of the loading machine, the throat of acceptance in the process of breaking and the process of laying the material on the roadway base.

To meet the requirements according to the mechanism, will be chosen according on that, the drilling diameter, the burden (W), the distance between rows (b), the distance between drillings in the row (a), the angle of drilling (β), the stemming length and sub drilling length.

Drillings will placed in the form of chess.

The number of rows is determined by calculating the burden [W], as well as on the specific charge of the explosive.

The drilling and blasting geometry is determined by the requirement to achieve a degree of crushing of the material with a minimum residue of the blocks.

The calculation of drilling parameters for production part

The European Standards for road construction are that the pieces of rocks do not exceed the size 500 [mm], this applies to place the material on the roadside base. In according on this are calculated all parameters of production drillings and are adopt like below.

The burden is: W = 2.8 [m], the distance between rows is: b = 2.8 [m], the distance between drillings in the row is: a = 2.8 [m], the diameter of drilling is: d_d = 89 [mm], the length of sub drilling l_{sd} = 0.50 [m], while for each row in follow the length of sub drilling will be added for 0.20 [m], and the angle of drilling is: β = 63^0 according to the project of motorway.

This calculation of drilling geometry that has been made above is valid for ANFO's domestic production explosive labelled ANFOKOS, which is an industrial explosive and has 2900 [m/s] detonation velocity.

Considering the width of the exploitation block which is 8.4 [m], when the product drillings are parallel to the contour drillings, the drillings will be made in three rows, in such a way that the effective length of drillings of rows taking consideration the sub drilling for each row will be:

$$l_d = \frac{h + l_{sd}}{sin\beta} \tag{2}$$

The calculation of contour drilling parameters

In order to have good results of cutting the massif with contural drillings it is important to select the appropriate drilling parameters: drilling diameter (d_{cd}), the distance between contour drillings (a_k), the distance between the contour drillings and the product drillings (b_k), the sub drilling (l_{sd}) and the drilling angle that should be according to the project.

Based on the tests made on the contural blasting's in the Kosovo Motorway Project, these results have been achieved in determining the parameters of contural drillings.

The diameter of contural drilling, calculated based on the cartridge diameter:

$$d_{cd} = (1.5 \div 3) \cdot d_{ec} \tag{3}$$

This applies to the explosive cartridges of d_{ec} = 25 [mm] to d_{ec} = 32 [mm]. Appropriated d_{cd} = 76 [mm].

Drilling machines that are in use are foreseen for larger drilling diameters and 76 [mm] drilling diameter is used. The distance between contural drillings calculated based on the drilling diameter:

$$a_k = (8 \div 14)\ d_{cd} \tag{4}$$

The distance between product drillings and contural drillings assigned based on the distance between contural drillings and drilling diameter:

$$b_k = (2 \div 3.6) \cdot (a_k + d_{cd}) \tag{5}$$

When the product drillings are parallel to the contour drillings, appropriate b_k = 2 [m].

The length of the contour drilling, will calculating in this form when the product drillings are parallel to the contour drillings:

$$l_{cd} = \frac{h + l_{sd3}}{\sin\beta} \tag{6}$$

In the case where the product drillings are parallel to the contural drillings, the contural drilling is equals the last row of the product drilling or increases by 0.2 [m].

Based on the equations above are calculated all parameters of the drilling for production part and for contour part, and these results are presented on table 1.

Table 1: The geometrical parameters of drilling, when the production drillings are parallel to the contour drillings

Parameter	Symbol	Value	Unit
The height of the bench	h	10	m
The diameter of production drillings	d_d	89	mm
The diameter of contural drillings	d_{cd}	76	mm
The diameter of the cartridge for production drillings	d_e	89	mm
The diameter of the cartridge for contour drillings	d_{ec}	28	mm
The angle of drilling	β	63	^{0}
Burden	W	2.8	m
The distance between drillings in the row, for product	a	2.8	m
The distance between rows, for product	b	2.8	m
The distance between drillings in the row, for contour	a_k	0.75	m
The distance between the product and the contour	b_k	2.0	m
The length of drilling for the first row	l_{d1}	11.8	m
The length of drilling for the second row	l_{d2}	12.0	m
The length of drilling for the third row	l_{d3}	12.2	m
The length of the contural drilling	l_{cd}	12.2	m
Stemming	l_s	2.8	m
The number of the product drillings (3 rows x 14 drillings)	n_{pd}	42	Drillings
The number of the contour drillings (1 rows x 50 drillings)	n_{cd}	50	Drillings

On below in Photo1. is presented the process of drilling in line of contour, and in Photo 2. Are presented drillings on the field.

Photo 1: The drilling process of the contour drillings

Photo 2: View of the field with contural drillings

Based in parameters on Table 1. Will construct the schematic pattern of drillings, and the profile of the drillings. That schematic is presented on Figure 1.

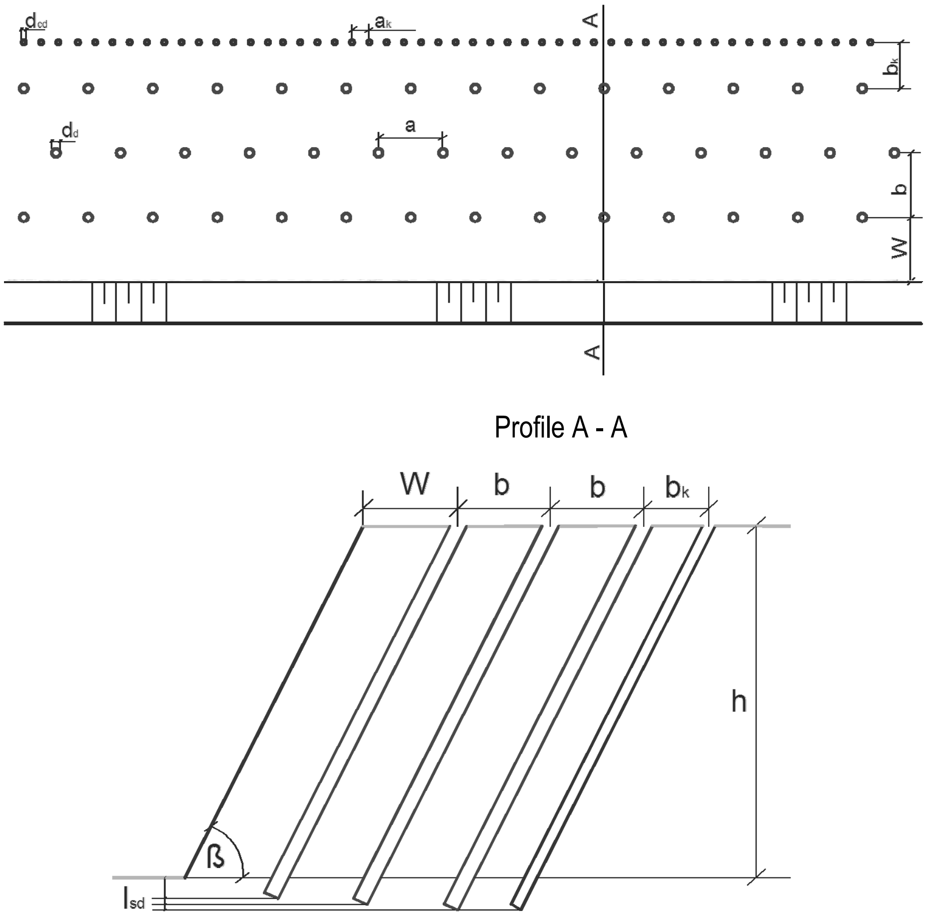

Figure 1: The schematic pattern of drillings and the profile A-A

Blasting's material

Based on these parameters when the product drillings are parallel to the contour drilling, in continuation will do presented the calculation results of the amount of material that is necessary to do the blasting.

The specification of the overall material required for blasting and initiating this field with the Nonel system, when the product drillings are parallel to the contour drillings, is:

Table 2: Quantity of material for blasting

Name of material	Quantity	Unit
ANFOKOS	1950	kg
EMULEX_1 (6 boxes · 24 kg)	144	kg
EMEX	125	kg
Detonating Cord	750	m
Nonel detonators U 475	42	piece
Nonel detonators U 500	42	piece
Nonel Connectors	46	piece
Dynoline	300 (+300 reserve)	m

The filling and connecting of contour drillings

Filling the contour drillings

For the filling of the contural drillings, the EMEX explosive material and the detonating cord with a weight of 12 [g/m] are recommended.

The filling of the contour drilling is done by intermittently filling, by welded cartridges on detonating cord at specified distances from each other.

First, two (2) cartridges or a long cartridge of explosive are welded on detonating cord and together with the detonating cord are released until the end of the drilling (Photo 3.) and the cutting of the detonating cord is done by dropping it over the drilling surface as much as it is needed to connect to the main detonating cord line (Photo 4.), the same procedure continues in all other drillings. Then pull out the detonating cord together with the explosive material cartridges and by welding the other cartridges at certain distances, it is released slowly until the drilling end arrives and until all the cartridges for that drilling are welded to the detonating cord. The welding of the explosive cartridges to the detonating cord is done with the insulating adhesive, Photo 5.

At the top of the drilling must be left without filling 0.5 ÷ 0.6 [m], so as not to break the bench edge that is being created, Figure 2 and Photo 6.

Photo 3: The appearance of placing the first cartridge

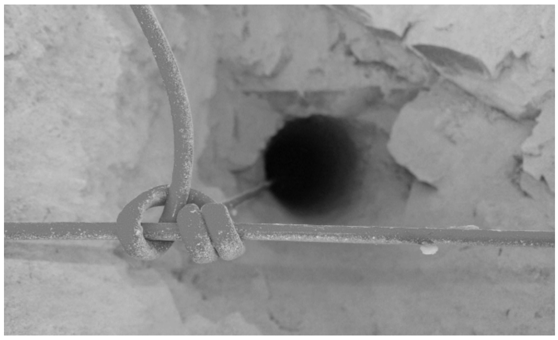

Photo 4: The appearance of the detonating cord connection

Photo 5. The procedure of filling the contour drilling

Photo 6. The length of the yarn pulled by holding the finger shows the distance of 0.6 [m] that remains without filling the top of the drilling

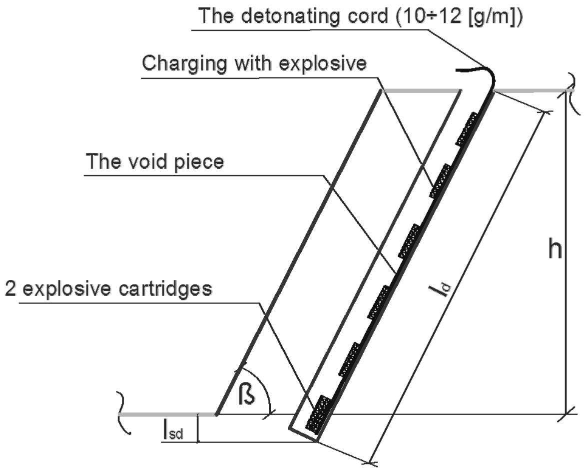

Figure 2: Schematic presentation of drilling filling of the contour drilling

The connection of the field with the Nonel system

To enable the safe initiation of the connection of the Nonel system, consideration should be given to the connection of Nonel detonators that are in the hole with Nonel connectors that are always on the surface and with the added care of connection tracking from one hole to the other and from one row to the other. Once all these operations have been carried out at each drilling and all connectors are aligned with each detonator in drilling, between them and the general yarn of the detonating cord yarn, the field is considered connected. The connected field looks like in Figure 3.

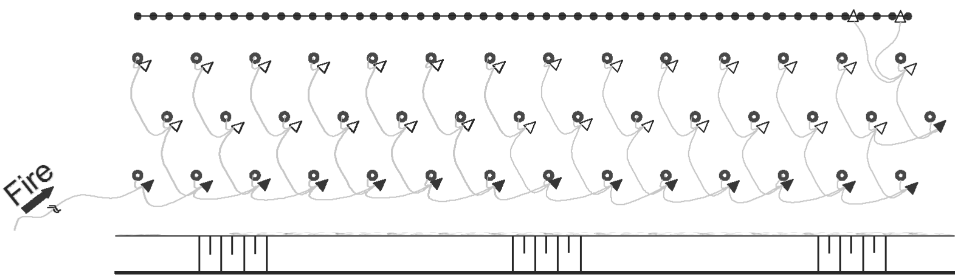

Figure 3: Schematic representation of the field connection with the Nonel system

Conclusion

From what is seen above, it also shows the great importance of having contour blasting, to form secure slopes, with a very high consistency, and enable for a very long time not to collapse the slopes.

All this is achieved if:

Collect very accurate data about environmental construction by conducting physical and mechanical analyzes of the environment. Where by determining the physical and mechanical characteristics, it is possible to determine the drilling parameters, the type of explosive material to be used and the method of initiation.

During determined the geometrical parameters of the field which is to be blasted, never allow to have more than 3 ÷ 4 rows of the product drillings before the contour drillings, all this to prevent the impact of the explosion forces in the part of the bench behind the contour line, respectively behind the contour drillings.

When determining the geometrical parameters of the drillings we have to ensure that the calculations are accurate and not to be assigned very small distances between the contour drillings or even very large distances, because if assigned very small distances between the contour drillings will lead to overburdening of explosive substances, which will lead to the break of the massif behind the contour line or to the collapse the bench. But if assigned the very large distances between the contour drillings, it is possible that the force of the explosion in the contour drillings will not be enough to make the cut of the massif.

During the connection of the field, it is determined the regular order of the ignition, because if we allow drillings of the product to ignite before the contour drillings, then the first will affect the rock mass crack behind the contour drilling. For this we must be careful that during the determination of the ignition order, always make such a connection to first ignite the contour drillings and afterwards to ignite drillings of the product.

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