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*Research Paper*

# The Determination of Optimal Parameters of the Geometry of Contour and Production Drillings

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**Abstract:** With the application of contour blasting's, we manage to make the cutting of the rock mass in the designed line, forming safe benches and slopes, which can resist for a very long time without collapsing and changing their shape. The choice of optimal parameters of the geometry of contour drillings and production drillings enables very good cutting of the rock mass and enables us to have a very good fragmentation of the rock mass, which enables us to make loading and haulage of the rock without any problems. As the optimal parameters of contour drillings and production drillings, for our case are ac= 0.75 [m], $b_c$ = 2.8 [m], $d_{hc}$= 76 [mm], a=2.8 [m], b = 2.8 [m], W = 2.8 [m] dhe $d_h$ = 89 [mm].

***Key words:*** *Powermite Max, Anfokos, drilling, geometry, contour, blasting*

## Introduction

Contour blasting's are of great importance for the construction of final road slopes, which must be stable and have a high stability, as they must not collapse as long as the road is used.

For this reason, the determination of the optimal parameters of the geometry of the contour drillings and production drillings has been taken into consideration, where as a case study the part of the highway that passes through the village of Bellanica has been taken.

This part of the highway passes through slab limestone rocks, which are quite unstable and always tend to slide, because the structure of their construction is layered and the angle of inclination of the layers is in the direction of the highway, which negatively affects slope stability.

During the execution of contour blasting's in such terrains, there are always problems in cutting the rock and leaving the benches in the designed parameters and in the designed line, because in some cases due to overloading of the cutting forces we have damage to the bench which is in construction and on the contrary if the cutting forces are smaller than the resistive forces of the rock, then we will have poor cutting of the bench, which then affects to narrow the track of the road and for its adjustment need for additional work arises.

To avoid these problems in the continuation of this paper, the optimal parameters of the geometry of contour drillings and production drillings at contour blasting's will be determined.

### 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 companies which operate on these works, possess a hydraulic hammer for breaking blocks.

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

$$D = K_0 \cdot \frac{C \cdot \gamma}{\Delta}, \qquad \left[\frac{m}{s}\right] \tag{1}$$

D – Detonation velocity of explosive, [m/s]
Δ– Density of explosive, 0.85 ÷ 1.25 [g/cm$^3$]
γ - Volumetric weight of rock 2.6 ÷ 2.7 [g/cm$^3$]
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.

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Where we have:

$$D = (0.63 \div 1) \cdot \frac{(1800 \div 2000) \cdot (2.6 \div 2.7)}{0.85 \div 1.25} = 2359 \div 6353 \left[\frac{m}{s}\right]$$

Considering the results obtained which condition the choice of type of explosive as well as taking into account the hitherto successful practice of applying the explosive "ANFOKOS", it is recommended that this type of explosive or explosive be another name depending on manufacturers, but having characteristics roughly the same as "ANFOKOS", used for blasting operations on highway works.

**Selection of the explosive for contour drillings**

Since the benches at the final contours of the highway are predicted to remain stable for a long time, how much will the highway used, in order not to have demolition of terrain contours around track, then required to have high security, not to have large cracks on benches and no hanging stone, then later to have falling 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):

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

D – Detonation velocity of explosive, [m/s]

Δ - Density of explosive, 1 ÷ 1.27 [g/cm$^3$]

γ - Volumetric weight of rock 2.6 ÷ 2.7 [g/cm$^3$]

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.

Where from the results obtained from the experience on the contour blasting's the coefficient values are acquired (0.85 ÷ 1.2).

Taking into account the results obtained which condition the choice of type of explosive as well as taking into account the hitherto successful practice of applying the explosive "Power mite Max", it is recommended that this type of explosive or explosive be another name depending on manufacturers but having characteristics similar to those of "Power mite Max", used for contour blasting works on the highway.

**The calculation of drilling parameters for production drillings**

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 = 90$^0$ according to the method of application. 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 10.4 [m], when the production drillings are vertically, the drillings will be made in four rows, in such a way that the effective length of drillings of rows taking consideration the sub drilling for each row will calculated by equation (2):

$$l_{d1\div3} = \frac{h + l_{sd}}{sin\beta} \tag{2}$$

The burden is calculated by equation (3):

$$W = 53 \cdot k_t \cdot d_h \cdot \sqrt{\frac{\Delta}{\gamma}} \ , \qquad [m] \tag{3}$$

Where are:
$k_t$ – Coefficient (0.9 ÷ 1.1)
$d_h$ – Drilling diameter, [m]
Δ – Density of explosive, [g/cm$^3$]
γ – Volumetric weight of rock, [g/cm$^3$]

The distance between rows is calculated by equation (4):

$$b = (0.85 - 1) \cdot W \ , \qquad [m] \tag{4}$$

The distance between drillings on the row is calculated by equation (5):

$$a = m \cdot W \ , \qquad [m] \tag{5}$$

Where is:
m – Coefficient of approaching of drillings (0,75 – 1,5).

In this case, a drilling with a depth of 3 ÷ 4 [m] should be drilled before the contour drilling, because the surface part between the production drillings and the contour drillings remains too far apart and large blocks may have after blasting.
The length of short drillings which are in front of contour drillings, near of them is calculated by equation (6):

$$l_{d4} = tan\beta \cdot b_c - tan\beta \cdot b_{cd} \ , \qquad [m] \tag{6}$$

Where are:
$b_{cd}$ – The distance between the product drilling and the contour drilling, in the end of product drilling
$b_c$ – The distance between the product drilling and the contour drilling, in the surface.

**Calculation of contour drilling parameters**

In order to obtain good mass cutting results with contour drillings it is important to select the appropriate drilling parameters: drilling diameter ($d_{hc}$), distance between contour drilling ($a_c$), distance between contour drilling and drilling of product ($b_c$), sub drilling of the contour drilling ($l_{sdc}$) and drilling angle which should be as per project.
The drilling diameter is calculated based on the diameter of the patron, and is calculated by equation (7):

$$d_{hc} = (1.5 \div 3) \cdot d_{pc}, \qquad [mm] \tag{7}$$

Where is:

$d_{pc}$ – The diameter of explosives cartridge for contour drillings, mm

The distance between the contour drillings is calculated based on the diameter of the contour drilling, and is calculated by equation (8):

$$a_c = (8 \div 14) \cdot d_{hc}, \qquad [m] \tag{8}$$

The distance between product drillings and contour drillings will calculated based on the distance between contour drillings and diameter of contour drillings, and is calculated by equation (9):

$$b_c = (2 \div 3.6) \cdot (a_c + d_{hc}), \qquad [m] \tag{9}$$

The results of calculations for optimal parameters of production drillings and contour drillings are presented on the table.1.

And based on the table.1. is designed the field of contour blasting, which is presented on Figure 1. in 3D and Figure 2. in 2D.

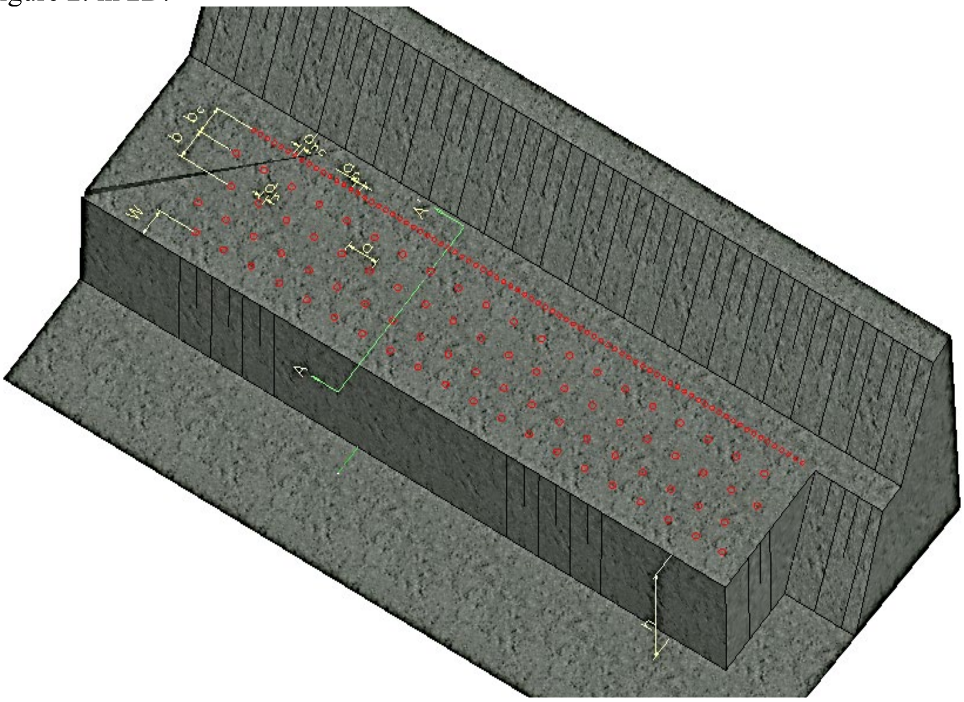

**Figure 1.** The field of the blasting designed in 3D

**Table 1.** Optimal parameters of contour drillings and production drillings

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Height of the bench | H | 10 | m |
| Diameter of drilling of product | $d_h$ | 89 | mm |
| Diameter of contour drilling | $d_{hc}$ | 76 | mm |
| Patron diameter for product drilling | $d_p$ | 89 | mm |
| Patron diameter for contour drilling | $d_{pc}$ | 27 | mm |
| Drilling angle for product drillings | β | 90 | $^0$ |
| Drilling angle for contour drillings | α | 63 | $^0$ |
| The burden | W | 2.8 | m |
| The distance between drillings in row for product drillings | a | 2.8 | m |
| The distance between rows for product drillings | b | 2.8 | m |
| The distance between drillings in row for contour drillings | $a_c$ | 0.75 | m |
| The distance between product and the contour drillings | $b_c$ | 2.8 | m |
| The length of drilling for first row | $l_{h1}$ | 10.5 | m |
| The length of drilling for second row | $l_{h2}$ | 10.7 | m |
| The length of drilling for third row | $l_{h3}$ | 10.9 | m |
| The length of drilling for fourth row | $l_{h4}$ | 4 | m |
| The length of contour drilling | $l_{hc}$ | 12.5 | m |
| Number of production drillings (4 rows x 20 drillings) | $n_h$ | 80 | Drillings |
| Number of contour drillings (1 row x 80 drillings) | $n_{hc}$ | 80 | Drillings |

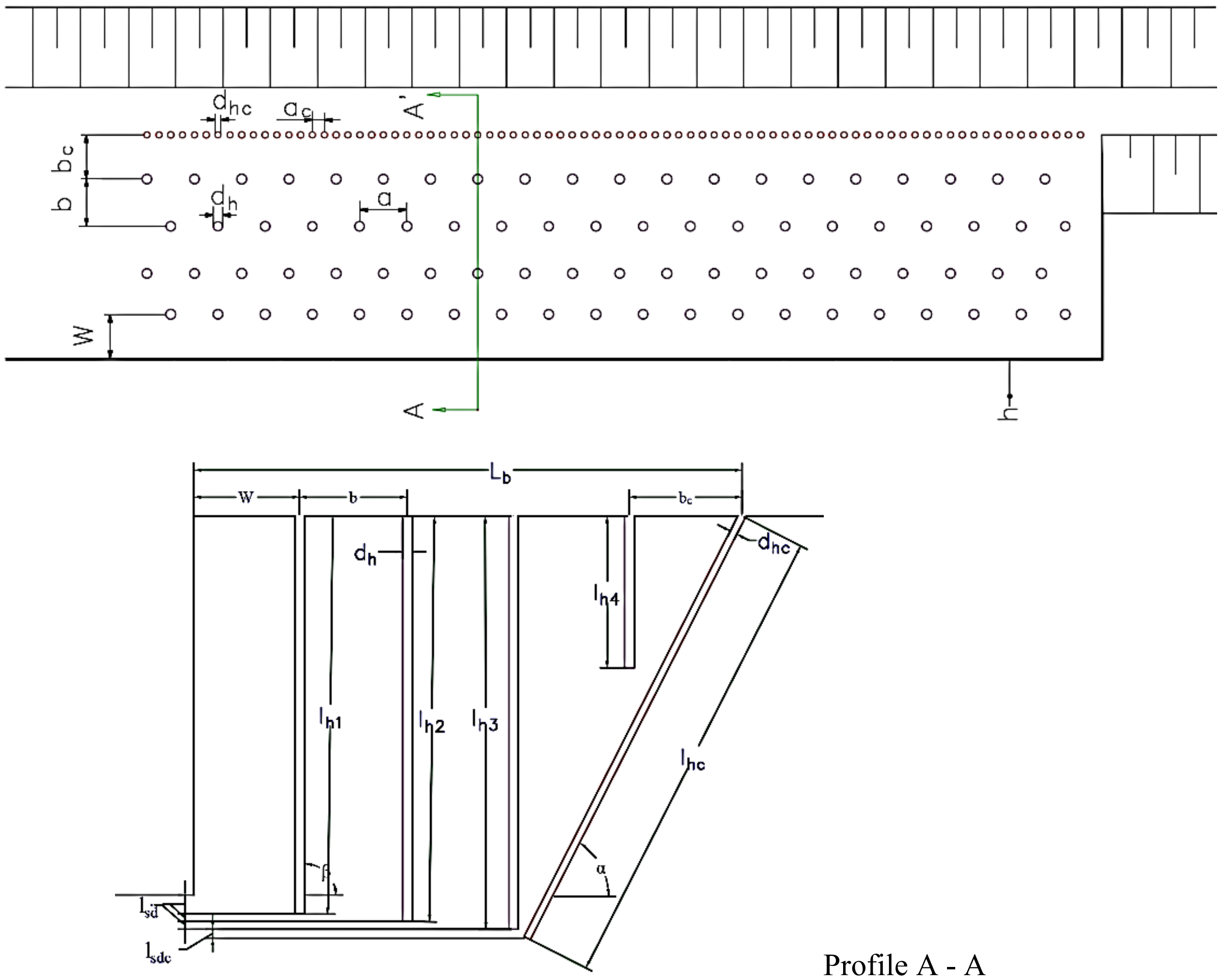


**Figure 2.** The field of the blasting designed in 2D and the profile A – A'

## Results and Comments

After making a large number of calculations to determine the distance between the contour drillings and the drilling's diameter of the contour drilling, the results of these calculations were transferred to the Grapher software and a diagram was obtained which is presented in Figure 3., which presents the relationship between drilling diameter and the distance between contour drillings, also enables us to determine these two parameters without having to do calculations.

According to Figure3. the values that must have the parameters shown in the diagram must be within the shaded area, which are in function of each other.

After making a large number of calculations to determine the distance between contour drillings and production drillings, the results of these calculations were transferred to the Grapher software and a diagram was obtained, which is presented in Figure 4., which presents the relationship between the diameter of the drilling, the distance between contour drillings in the row, and the distance between the contour drillings row and the production drillings row, also enables us to determine these parameters without having to do calculations.

According to Figure 4. the values that must have the parameters shown in the diagram must be within the shaded area, which are in function of each other.

Also, the number of production rows before contour row is of great importance, as this directly affects the blasting results, affects the cutting quality of the rock mass and affects the stability of the bench. Based on the results of the blasting's carried out on highway project on the Bellanica, the maximum number of rows of the production drillings before contour drillings should be 4 (four) or less, because this affects the material mined in the production part, to be thrown forward, and not to affect the surface of the bench which is in formation.

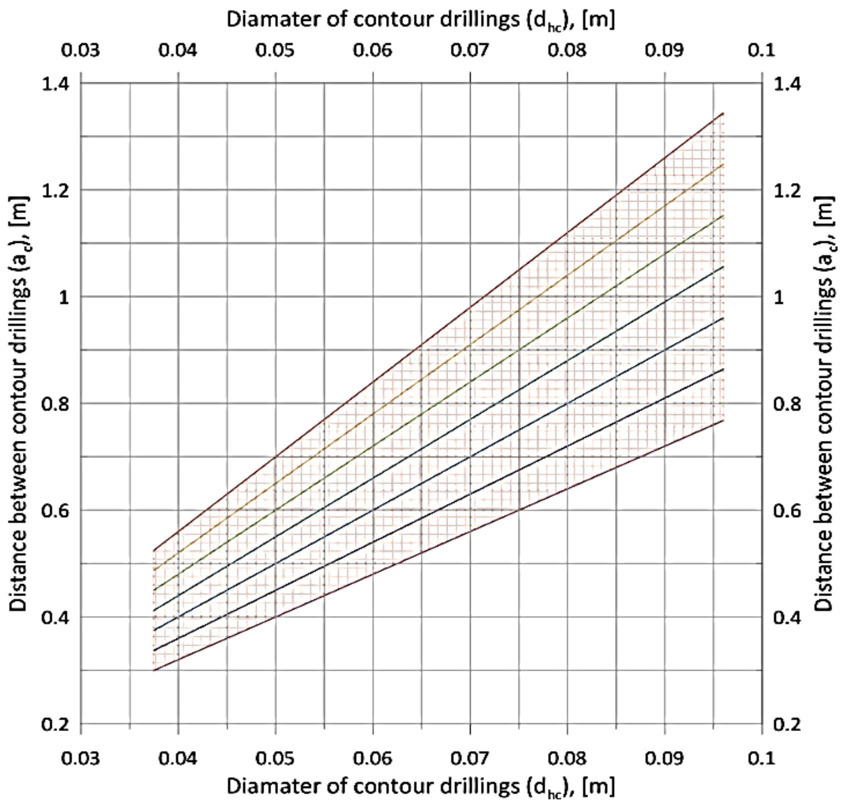


**Figure 3.** Diagram of determining the diameter of the drillings and the distance between the contour drillings in row

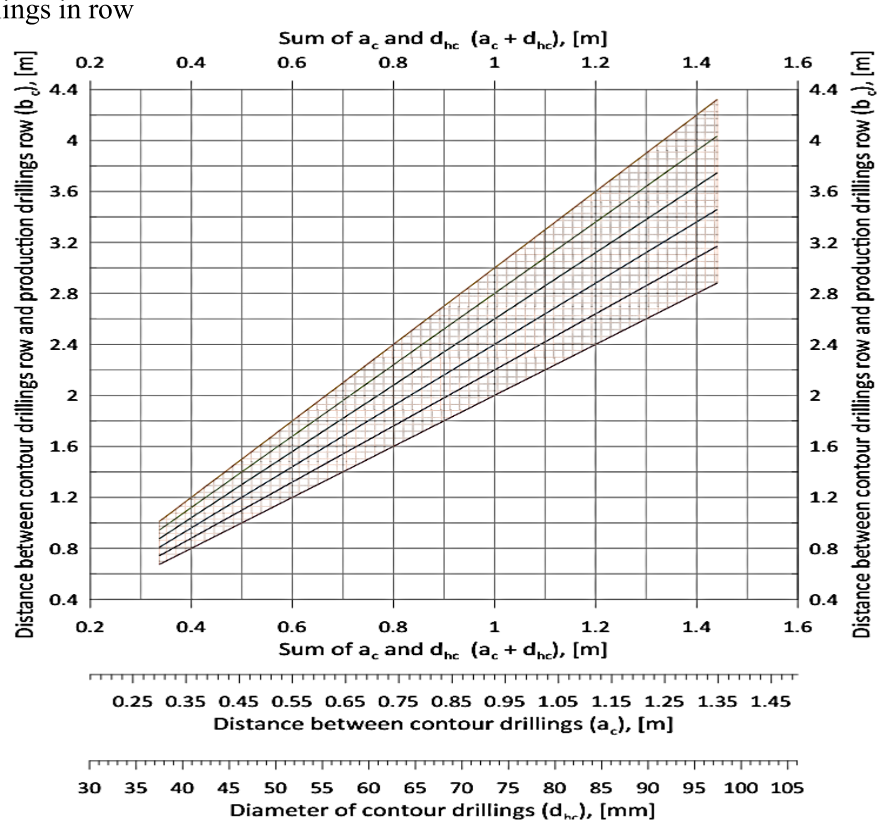


**Figure 4.** Diagram for determining the distance between the contour drillings row and the production drillings row

By applying the optimal parameters of contour drillings and production drillings, which are presented in Table 1. It was achieved that to do cut the rock mass without causing cracks, and to formed regular and safe benches. Where these results can be seen in the following figures from Figure 5. to Figure 8.

**Figure 5.** View of a case of contour blasting

**Figure 6.** View from the results of contour blasting

**Figure 7.** The view after removing the mined material of cutting the bench with contour blasting

**Figure 8.** View of traces of contour drillings on the bench forehead

## 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 analyses of the environment. Whereby 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.

If during determined the geometrical parameters of the field which is to be blasted, never allow to have more than 3 ÷ 4 rows of the production 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.

If, 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.

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