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# DESIGN OF CONTOUR EXPLOSION PARAMETERS

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**ABSTRACT**
In this article, it is established that the distance between the contouring and the first row of auxiliary holes is determined by the value of the line of least resistance. The horizontal distance between the auxiliary holes is equal to the size of the fracturing zone.

**Keywords:** borehole, rock type, density, crack, contour charges, contour holes, working out, penetration, standard enumeration, fissuring, charge initiation.

To obtain workings with minimal deviations from the design contour and maximum safety of the near-contour massif, the technology of contour blasting should be used. The following options for contour blasting are possible:

-A method of preliminary slot formation, in which contour charges are initiated before loosening charges, or before they are drilled. This method is advisable to apply in fractured and heavily disturbed rocks for contouring the walls of underground workings of lower ledges and complex figured recesses, as well as for protecting individual elements of structures from seismic loads;

- A method of subsequent contouring, in which contour charges are initiated last (contour breaking method).

On the basis of production experience, the following methods for implementing the contour blasting technology are recommended, used in both variants of contour blasting:

- The method of close charges, in which contour holes are charged with charges with a loading density reduced in the axial direction (dispersed charge) or reduced in the radial direction (the presence of an annular gap between the charge and the walls of the hole). The distance between the contour holes in this case is much smaller than in conventional blasting. In addition, it is possible to have uncharged holes located between the charged holes [1].

Breaking charges with a lateral cumulative recess;

- Blasting method based on boreholes with profile cuts oriented along the contour of the working. The drilling of such holes should be carried out by concentrator formers designed by TsNIIS and the former.
- A method of blasting with a protective layer, in which the contour holes are located at a distance of 0.2 ... 1.0 m from the contour line, and the part of the rocky soil remaining after the explosion is finalized in a non-explosive way.

The technology of contour blasting is implemented by the following set of measures, the mandatory implementation of which is a guarantee of success:

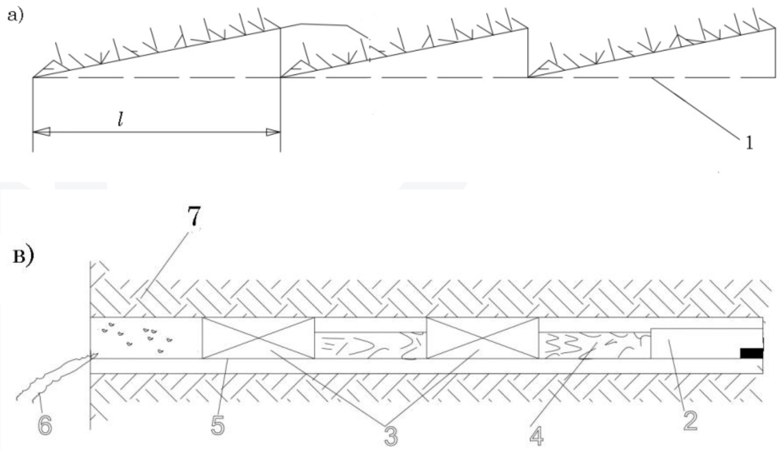
a) The exact location of the mouths of the holes on the face plane and their exact orientation in space.

Deviations of the mouths of the holes at the bottom when they are drilled and marked should not exceed 5 cm.

The exact orientation of the holes in space must be ensured by maintaining a constant angle of inclination of the axis of the contour holes to the bottom (drilling plane). The value of this angle depends on the method of fastening and the type of support, the length of the entry and the design of the drilling machine.

Drilling rigs must have devices that allow maintaining this angle of inclination constant when moving the manipulator with a hammer drill from hole to hole. In the absence of such installations, contour holes should be drilled by experienced drillers.

On fig. 1, a shows the layout of contour holes for the case when the type of lining allows you to place the mouths of these holes on the line of the design contour;




**Rice. 1. Location of contour holes and design of charges for contour holes:**

*l-setting; c - normative enumeration; 1 - design contour; 2 - fighter; 3 - explosive cartridges; 4 - false cartridges; 5 - detonating cord; 6 - wires; 7 - stemming.*

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*b) A decrease in the distance ak between contour holes in comparison with non-contour (ordinary) blasting [2].*

When determining the distance between the contour holes, it is recommended to assign the value of the coefficient of convergence of holes $m_к$ from table 1 (contour blasting by the method of subsequent contouring), and with the method of preliminary slotting, the distance $a_к$ between the contour holes is assigned from the condition $a_к$<(4….6)$d_ш$, where dsh-hole diameter.

Table 1.

| Soil strength according to M.M. Protodyakonov | 2-4 | 4-6 | 6-8 | 8-10 | 10-12 | Over 12 |
|---|---|---|---|---|---|---|
| $a_к$, см | 70 | 65-60 | 60-50 | 50-40 | 40-30 | 30-20 |
| $m_к$ | 1.3-1.2 | 1.2-1.1 | 1.1-1.0 | 0.9 | 0.85 | 0.8-0.7 |

The best contouring is provided if the condition is met (see Fig. 1):

$$m_к = \frac{a_к}{W_к} \approx 0,8 \ldots .1,0. \qquad (1)$$

в) a decrease in the concentration of explosives per 1 m of the length of the contour hole, i.e., a decrease in the linear charge density, which is recommended to be assigned in accordance with Table. 1. In the absence of such charges, it is possible to use low-bristle types of explosives, for example, ПЖВ-20 ammonite or Э-6 coalite. It is most expedient to use special charges for contour blasting, for example, CBCCh charges (contour blasting core charge), having a diameter of 24 mm and schematically shown in fig. 1, c. In the absence of CBCCh charges, charges for contour holes can be made from standard explosives. In such cases, explosive cartridges are dispersed using false cartridges (see Fig. 1), or they are fixed at intervals on a wooden rail, which, when placed in a hole, is oriented towards the protected array. The latter is possible with such a combination of the dimensions of the hole with the dimensions of the explosive cartridges, taking into account the thickness of the rail and the thread of the EC, which will ensure unhindered placement of the charge in the hole [3].

The length of false cartridges or air gaps must not exceed the length of explosive cartridges.

Table 2.

| Soil strength according to M.M. Protodyakonov | 2-4 | 4-6 | 6-8 | 8-10 | 10-12 | 14 or more |
|---|---|---|---|---|---|---|
| γ, кг/м | 0.2-0.3 | 0.35-0.45 | 0.45-0.55 | 0.55-0.6 | 0.6-0.65 | 0.65-0.7 |

d) Initiation of charges of contour holes by electric detonators of one stage of deceleration. In general, when choosing the deceleration intervals between the time of initiation of contour and auxiliary charges, one should proceed from the condition of eliminating the influence of the clamp, i.e., blasting contour holes should be carried out in free space (for the method of subsequent contouring).

Based on the experience of pre-slit blasting technology, the deceleration between the contour and pre-contour rows should be at least 75 ms in weak rocks and 50 ms in hard rocks.

Experience in the construction of BAM tunnels has shown that when applying the method of subsequent contouring in rocky soils with a strength coefficient according to M.M. pre-contour - 250-500 ms (the diameter of the contour holes exceeded the diameter of the explosive cartridges by 1.6÷1.7 times).

The optimal deceleration interval, as well as the feasibility of using stemming in contour holes, should be established by experimental explosions;

e) operational control over the quality of delineation of mine workings, carried out by the surveyor service, and on its basis, operational adjustment of the parameters of the VR.

The main means of operational control over the quality of the contouring of workings should be considered the assessment of the surface roughness of the contour, characterized by the percentage of traces of holes left after the irregularities between the traces of holes [4].

The results of contour blasting should be considered satisfactory if the following conditions are met:

$$У_ф \geq У \quad (2)$$

$$h_ф \leq h \quad (3)$$

where $У_ф$ is the actual percentage of hole marks on the contour, determined by the formula:

$$У_ф = \frac{L_ф}{L_ш * \eta} * 100\%, \quad (4)$$

$L_ф$—the sum of the lengths of all traces of holes left on the contour (except for the bottom ones), measured by a mine surveyor, m; $L_ш$ - total length of all contour holes (except plantar holes), m; $\eta$ - hole utilization rate; $h_ф$— actual average value of irregularities on the surface of the contour, cm (Appendix 4); У - the minimum allowable percentage of hole marks for contour blasting on the working contour, determined by the formula:

$$У = 4.83Т + 0.52f + 30.2; \quad (5)$$

h - the maximum allowable average value of irregularities for contour blasting, determined by the formula:

$$h = 1.08T + 0.66f + 13.23 \text{ sm}; \quad (6)$$

$f$ — soil strength coefficient according to M. M. Protodyakonov; T— fracture category of the rock mass according to the classification of the Interdepartmental Commission on Explosives (Appendix 1).

Attachment 1

Fracturing of mountain ranges according to the classification of the interdepartmental commission on explosives

| Category | The degree of fracturing (blockiness) of the massif | Average distance between fractures of all systems, m | Specific fracturing,, м⁻¹ | Acoustic indicator, $A_c$ | Content (%) in the array of units (blocks), mm | | |
|---|---|---|---|---|---|---|---|
| | | | | | 300 | 700 | 1000 |
| I | Extreme fracturing (small block) | Up to 0.1 | 10 | 0,1 | До 10 | 0 | No |
| II | Strongly fractured (medium block) | 0,1-0,5 | 2-10 | 0,1-0,25 | 10-70 | up to30 | up to 5 |
| III | Medium cracked-novaty (large-block) | 0,5-1 | 1-2 | 0,25-0,4 | 70-100 | 30-80 | 5-40 |
| IV | Finely cracked-novaty (very large-block) | 1,0-1,5 | 1,0-0,65 | 0,4-0,6 | 100 | 80-100 | 40-100 |
| V | Practical monolithic (exclusively large-block) | Over 1.5 | 0,65 | 0,6-1 | 100 | 100 | 100 |

In the presence of rocky soils, the structure of which does not allow traces of holes to remain after drilling, it is allowed to consider the results of contour blasting as satisfactory, provided that the condition [5] is met.

To ensure the possibility of using charges with a reduced loading density in contour holes without increasing the volume of drilling operations, holes with profile cuts oriented in accordance with the design contour of the mine should be used. In this case, the specific charge $q_K$ for the face area blasted by contour holes (see Fig. 1) should be determined by the empirical formula obtained by ЦНИИС:

$$q_{k=}q_o(0.8335 + 0.0336 * f - 0.0015 * f^2 - 0.1014 * H + 0.0037 * H^2 + 0.0018 * H * f), \quad (7)$$

where $q_o$ is the specific explosive charge, determined in accordance with clause 2.16, kg/m3;

H - notch depth, -mm (H=7-8 mm); $f$ - soil strength according to M. M. Protodyakonov [6].

The charge mass $Q_к$ of all contour holes when applying this method should be determined by the formula:

$$Q_к = \frac{q_к * S_к * l_{зах}}{N_к} \quad (8)$$

where $q_к$— is the specific charge of explosives, kg/m3, determined by formula (7); $l_{зах}$ - depth of entry, m; $S_к$ is the cross-sectional area of the face, m2, blasted by the charges of contour holes (see Fig. 1); $N_к$ - the number of contour holes, determined by the formula:

$$N_к = \frac{П}{a_к} \quad (9)$$

where П is the working perimeter, m.

Conclusions. If the number of holes during their arrangement turns out to be non-integer, then it must be rounded up to the nearest integer number of holes, and the interval between the holes is recalculated so that the distances between the contour holes operating under the same conditions are equal. The change in the distance from the calculated parameter is permissible by no more than ±10%.

The distance between the contouring and the first row of auxiliary holes is determined by the value of the line of least resistance. The horizontal distance between the auxiliary holes is equal to the size of the fracturing zone.

The number of holes and the distance between them is calculated in the same way as in the case of contour holes. Taking into account these parameters, the location of contouring and auxiliary holes is determined along the section of the working.

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