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Determination of the Rational Length of Clay and Sand-Clay Holestemmings

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TSTU named after I Karimov. Tashkent

Abstract: The required length of the stemming is determined by the quality of the explosive used (the pressure of the detonation products in the charging chamber and the speed of detonation of explosives), the physical and mechanical properties of the stemming materials (the volume weight and intensity of internal friction forces), the length of the charge, the direction of its initiation, as well as the hardness of caved rock, quantity of free face end, line of least resistance.

Keywords: hole diameter, explosive, length of the stemming, detonation, loaded length, line of least resistance, initiation of charge, rockgrinding.

Long-term research by many authors [1,2,3,4,5] has established that the stemming during the mine drivageby drilling and blasting method prevents energy losses during the detonation of the explosive charge, providing greater completeness of its detonation and the release of the maximum value of its potential energy, increases the effective length of the blast wave of the explosion and the initial pressure of the explosion gases, increases the duration of the piston action of the detonation products on the walls of the charging cavity and the length of radial cracks formed during explosions of charges.

Perennial practice of blasting during underground mining operations, as well as special experimental and analytical studies indicate that with a good quality of the stemming material sand sufficient length, the stemming is so compacted in the holes that the resulting friction exceeds the ejection effect of the detonation products. Such stemming forms a dense wedge in the hole, which does not fly out of the hole, but moves along with the destroyed massif [6].

When implementing stemming from plastic or granular materials, it is known to be tightly wedged in the hole as a result of compaction under the influence of an explosion.

The main compaction of the stemming material occurs at the initial moment of explosion development due to the impact of shock waves and piston pressure on the face of the stemming of the detonation products. As a result of this compaction, the force of the lateral pressure occurs at the contact of the stemming with the walls of the drill hole.

The process of ejecting the stemming from the hole can be represented as follows. Since the beginning of the detonation of the explosive charge, the gaseous products of detonation, acting on the face of the stemming, tend to move it. Until the displacement occurs, the resistance to the ejecting action of the detonation products is due to the inertia of the rest of the own weight of the stemming, the forces of internal friction and the adhesion of the particles of the stemming material. But immediately after the last compaction, the stemming is shifted and in the future its movement is prevented only by weight and internal friction forces. The scheme of the forces acting on the face during the explosion of the blast-hole is shown in Fig. 1.

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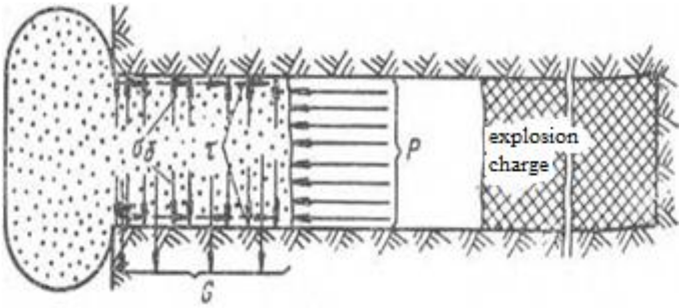

Рис.1. The scheme of the forces acting on the stemming from plastic or granular materials during the explosion:

$\sigma_б$ — lateral pressure forces; τ — displacement resistance of the stemming material; G —weight of the stemming; P — average pressure of gaseous detonation products.

The existence of optimal values of stemming from the point of view of obtaining maximum explosion effect is confirmed by experimental studies [7,8] which established that the yield of the coarse fraction with increasing length of stemming to a certain value decreases, then remains practically unchanged. On the contrary, the yield of small fractions with the increase in the length of the stemming has a tendency to rise. All this once again confirms that in each particular case, there is an optimal value of the stemming, which provides the maximum possible explosion effect inother equal conditions.

The minimum length of the locking face, i.e., such that a solid wedge is formed that does not fly out of the hole, can be determined from the condition that the total resistance of the friction forces on the shear surface of the stemming should be greater than or at least equal to the ejection effect of the detonation products

$\sum Q_{mp} \geq S$,(1)

Where Q_{mp} is the total resistance of the friction forces on the shear surface of the stemming, kg;

S–the ejection force of the detonation products, kg.

The left side of inequality (1) can be represented as an expression

$\sum Q_{mp} = \pi d l_з \tau_{mp}$,(2)

where$d$-hole diameter,*m;*

$l_з$-**length of the stemming**, *m;*

τ_{mp}-the intensity of the internal friction forces of the stemming material compacted in explosion, kg/m^2.

The ejecting force of the detonation products S in the case of an application of plastic (clay or sand-clay) stemming, when the face mass completely covers the cross section of the drill hole and the face of the stemming directly adjacent to the charge can be considered as a solid piston, will be

$S_{пл} = \frac{\pi d^2}{4} P$, (3)

Where P-the average pressure of the detonation products in the hole, kg/m^2.

When the stemming is made of granular materials with a certain porosity, the force S that ejects the stemming out will be less, since the face of the stemming will perceive the pressure of the detonation products not as a solid piston, but as a piston with holes.

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Therefore, the force of the detonation products, ejecting out of the drill hole stemming of granular materials, is determined by the expression

$S_{зер} = \frac{\pi d^2}{4}P(1\text{-}K_n)$, (4)

whereK_n-porosity coefficient of the grained stemming material. For sand with medium strengthK_n= 0,3-0,4.

Then taking into account the expressions (2), (3), (4) the inequality (1) for plastic and granular stemming materials can be represented as follows

$l_з\tau_{mp} \geq \frac{Pd}{4}$, (5)

$l_з\tau \geq \frac{Pd}{4}(1\text{-}K_n)$, (6)

From the expressions (5) and (6) it is not difficult to determine the minimum length of the locking hole of the non-flying plug. However, experimental studies of the authors [3] indicate that a certain part of the stemming adjacent directly to the hole mouth, after 0.4—0.5 ms from the moment of the charge detonation, is torn off and under the influence of reflected shock waves is ejected from the hole. Therefore, when determining the minimum length of the stemming that forms a non-flying plug in the hole, expressions (5) and (6) must be corrected to take into account the detached part of the stemming material. As a result, the following expressions can be obtained for determining the length of a plastic and grained stemming, respectively:

$l_{з.пл} \geq \frac{Pd}{4\tau_{mp}} + l_{з.отр}$, (7)

$l_{з.зер} \geq \frac{Pd(1-Kn)}{4\tau_{mp}} + l_{з.отр}$,(8)

where $l_{з.пл}$-the length of the stemming, at which a non-flying plug is formed, in the case of using plastic stemming materials, m;

$l_{з.зер}$-the same, when using grained stemming materials, m;

$l_{з.отр}$-the part of the stemming located at the hole mouth that is torn off by the action of reflected shock waves, m.

According to the authors [6],

Who studied the nature of the discharge from the hole stemming of various types, it was found that the value of $l_{з.отр}$for both plastic and granular at erialsis 20-40 cm. The calculation made according to formulas (7) and (8) shows that a plastic stemming, depending on the content of sand and clay, forms a plug that does not fly out of the drill hole at a length of 1,8-2,0 m. a plug of the same strength is formed at a length of 0,8-1,0 m in the case of using granular stemming materials. However, it is not possible to recommend formulas (7) and (8) for calculating the size of the hole stemming, since according to modern ideas about the mechanism of explosive destruction of rocks and the role of the internal stemming in this process, the use of an excessively long stemming, which remains stationary in the hole during the massif destruction, cannot provide optimal conditions for maximum use of the explosion energy.

To determine the rational length of the stemming it is advisable to use the formulated conditions for maximum use of the explosion energy the expressions of which are given below:

for direct initiation

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$v_\partial l_з = v_з(v_\partial t_p + l_{вв})$ (9)

for inverse initiation

$v_\partial l_з = v_з(v_\partial t_p - l_{вв})$ (10)

wherev_∂-the velocity of detonation of explosives in the charge, m/sec. the velocity of detonation of explosives in the charge is determined by the type of explosive used and in each case is a known value.

$v_з$–the ejection rate of stemming from the hole, m/sec;

t_{p}- time of separation and displacement of rocks, sec. According to MakNII [9], with a length of about 2 m t_{p} has the following values: in sandstones with one free face surface 4.3-10 msec, in the same rocks with two free face surfaces 0.2-12 msec; in clay shales with one free face surface 6-58 msec; in the same rocks with two free face surfaces 3-27 msec; in coal faces with one free face 9-33 msec.

$l_{вв}$-the length of explosive charge, m. The length of the explosive charge is set based on the number of holes and the value of the specific consumption of explosives, which is calculated using known formulas or accepted on the basis of practical data.

By combining the expressions (9) and (10) and substituting the values of the ejection rate of stemming into the resulting equation, we can obtain the formula[6] for determining the rational length of stemming for both direct and inverse charge initiation.

$l_з = \beta \sqrt[3]{\frac{Pd\,(v_\partial t_p \pm l_{вв})^2}{v_\partial^2 \gamma_з^2}} \sqrt[6]{\frac{P}{\tau_{mp}}}$, (11)

The plus sign in the expression under the cubic root refers to the case of direct initiation of charges, minus the inverse.

The value of the coefficient β is determined experimentally and is equal to: for a stemming made of plastic materials 0,47, for a stemming made of granular materials 0,54.

$\gamma_з$- the density of the stemming material, kg/m^3.

Analysis of formula (11) shows that the necessary length of the inner drill hole stemming is determined by the quality of the used explosives (pressure of the detonation products in the charging chamber and the velocity of detonation of explosives), physical and mechanical properties stemming materials (the size of volume weight and intensity of the internal friction force), the length of the charge and direction of initiation, as well as the hardness of caved rock**,** the number of free face end and line of least resistance.The last three indicators in formula (11) are taken into account by the time interval $\boldsymbol{t_p}$. The required length of the stemming is also affected by the diameter of the holes. This is due to the disproportionate growth resistance of friction forces to increase the ejection of the stemming the efforts of the detonation products with increasing diameter of the holes.If the latest increase helps the tamping force increases in proportion to the square of the diameter of the hole, the side surface of the stemming, and hence the total resistance of the friction forces increase proportionally to the first degree of the diameter of the hole. Formula (11) allows us to solve the question of the rational length of the stemming in each case, taking into account both the properties of explosives and the properties of the stemming materials.

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