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Determination of the Installation Density of Anchors in the Walls of a Working with a Quadrangular Cross Section

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Annotation: To date, a large number of works have been published in domestic and foreign technical literature devoted to determining the main parameters of the roof bolting. However, all these studies did not lead to the creation of a generally accepted theory of rock bolting and the development of an adequate calculation of its main parameters. A method for calculating the anchor bolting for vertical raisers has been developed, including the calculation of the density of anchors for vertical raisers of quadrangular shapes. A formula is proposed that determines the density of installation of anchors in the walls of a vertical working of a circular cross section, covering the radius of the zone of possible falls. The strength of the anchors in the wall of the working can be calculated by the formulas, depending on the type of anchors used.

Key words: rocks, rock pressure, workings, cross section, wall, fall, lining, anchor, installation density, safety factor.

Introduction

The installation of rock bolts is one of the most durable and reliable ways to support mountain ranges due to their high bearing capacity.

Anchor lining is a system of anchors fixed in boreholes and arranged along a certain grid. The anchors themselves are presented in the form of a rod or rod with a nut and a damping washer.

“Processing” is subjected to each face of a mine or mine. It is important that before starting work, the site must be brought to a safe condition. The roof of the working is tapped to reveal exfoliated rocks, drilling in which is unacceptable. Then holes are drilled in the roof for anchoring, glue is put into the holes, which is tightened with a nut and washer. The anchor lock is firmly fixed in the rocks surrounding the working. Thanks to the supporting elements of the rock, the roofs seem to be stitched together, due to which the rock mass is strengthened and its stability is increased. For greater efficiency, the sides and roof of the anchor bolts are treated with special compounds that inhibit the flow of oxygen into the rock layers.

The whole variety of anchor designs can be systematized as follows:

1. According to the material of the anchors - wood, metal, reinforced concrete, polymers, rubber, etc.

2. According to the type of rod - rigid, flexible.

3. By type of lock - single-lock, double-lock, multi-lock and lockless.

4. By type of lock - wedge, wedge-slot, spacer, screw.

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5. According to the method of fixing - mechanical, chemical, explosive, solutions.

6. By the number of rods - single-rod, two-rod, multi-rod.

7. By the type of supporting elements - with a spherical, flat, figured washer, etc.

Currently, metal, reinforced concrete, wood and steel-polymer anchors are used.

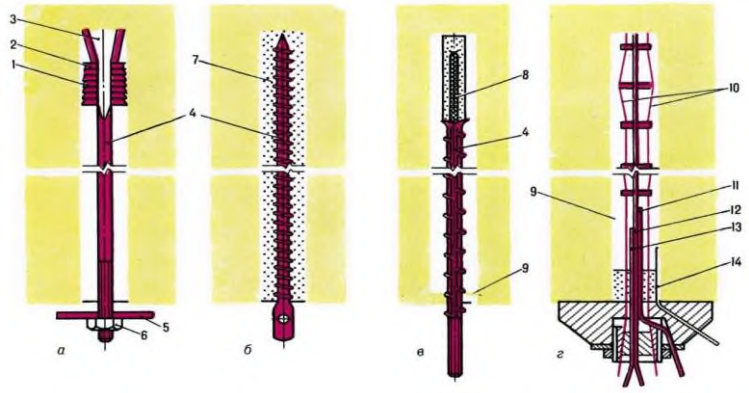

Fig.1. Scheme of installation in the well of expansion (a), stuffed (b), polymer concrete (c) and prestressed (d) anchors: 1 - wire ring; 2 - spacer sleeve; 3 - wedge; 4 - rod; 5 - base plate; 6 - nut; 7 - cement mortar; 8 - ampoule with resin, sand and hardener; 9 - sealing ring; 10 - bundle of high-strength wire; 11 - tube for secondary injection of the solution; 12, 13 - tubes for solution and air outlet; 14 - tube for the primary injection of the solution.

Detailed information about anchors, their design and methods of fastening are available in numerous literature devoted to the use of this type of fastening [1-7].

In recent years, anchor bolting has become more widespread [8].

The share of use of this support in some countries is given in Fig.2. For example, in the USA in 1951, 450 mines used anchor bolting, more than 35% of all mine workings were secured with it, and in 1991 – over 50%. It also occupies a dominant position in the mining industry. [9,10,11-28]

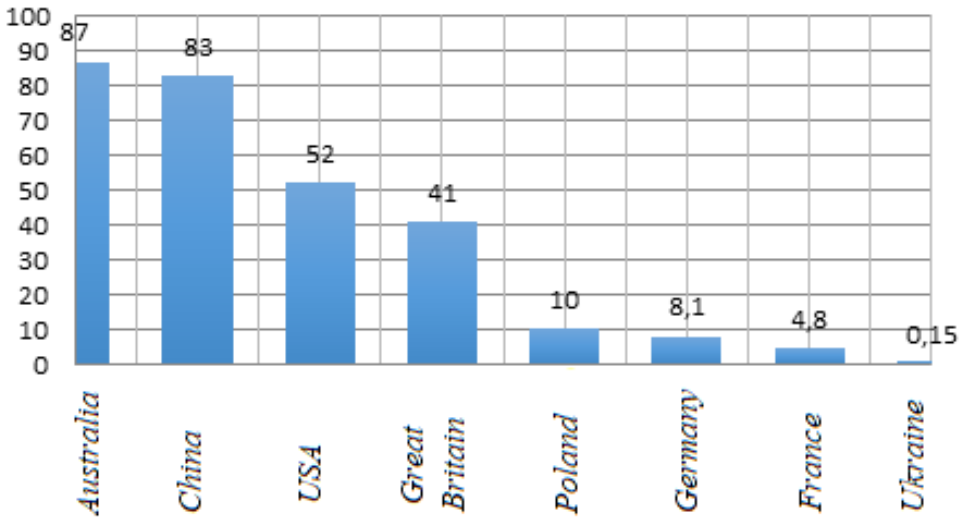

Fig.2. Percentage of workings fixed with anchor bolting.

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The process of installing composite anchors is fast and convenient. All activities for their installation are carried out in the following sequence:

1. A hole is being drilled.

2. Using a bolter or manually, special ampoules with a mineral or polyester composition are introduced into the hole.

3. The anchor is fixed in the hole, pre-equipped with a nut and a support washer.

4. After the composition of the ampoule has hardened, the nut of the anchor rod is tightened to the required values in order to create a primary tension.

As a result of the measures taken, the composite anchor becomes ready for applying loads. It can be used with equal success for mine workings in mines and mines.

Let's determine the density of installation of anchors for different mine workings:

Consider a mine working with a rectangular section. Let us determine the installation density of anchors in the walls of a working with a quadrangular cross section. We denote the width and length of the cross section, respectively, through m_1 and m_2 (Fig. 3). In this case, $m_2 \geq m_1$

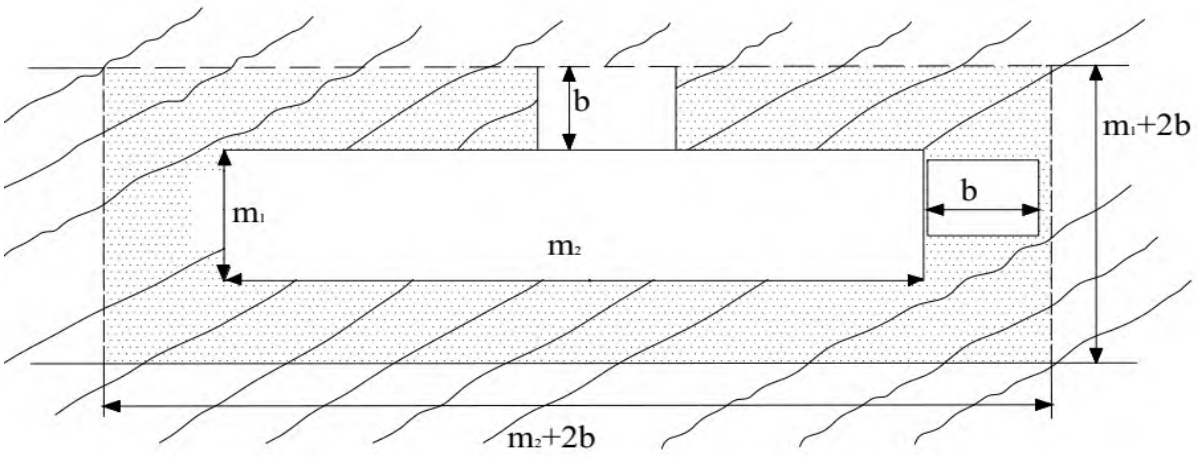

Fig.3. Installation of anchors in the walls of a working with a quadrangular cross section.

Research method

We apply the mathematical method of research, by which we determine the density of installation of anchors in a row in mine workings:

For mine workings of rectangular section. In this case, the volume of rocks located in the zone of possible falls between the anchor belts in width and length of the section are equal to:

$$V'_2 = m_1 bh, \text{ м}^3 \quad (1)$$

$$V''_2 = m_2 bh \quad \text{м}^3 \quad (2)$$

где: b – the size of the zone of possible falls, m; h – vertical anchoring step, m.

Equilibrium equation for rocks located along the length of the section m_2 taking into account rock pressure $\gamma_c hbm_2$ has the following form:

$$\xi k_z \left(Q''_2 + \gamma_c hbm_2\right) cos\varphi = N * P_{z.ст}$$

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где: N - number of anchors installed in the area m_2h; in addition to the site $Q''_2 = \pi(b^2 + 2bR)$ rock pressure also works; γ_c – density of wall rocks rising in the place of anchoring, $\frac{кг}{м^3}$; φ – rock bedding angle, deg; k_z – safety factor equal to 1.5 for development workings; ξ – called the lateral pressure coefficient or the lateral thrust coefficient. This coefficient shows what part of the vertical load acting at the considered point of the array is the forces or stresses acting in the horizontal plane. For rocks, the coefficient of transverse deformations ν varies from 0.08 to 0.5, respectively, the extreme possible limits of change ξ range from 0.1 to 1. It should be emphasized that, in accordance with the physical meaning of the coefficient ν, its values cannot exceed 0.5, and therefore the values of the lateral pressure coefficient ξ cannot be greater than 1.

Otherwise, the medium loses its continuity.

The last equation can be written as

$$2\xi k_z \gamma_c hbm_2 cos\varphi = N * P_{z.ст} \qquad (3)$$

Main results

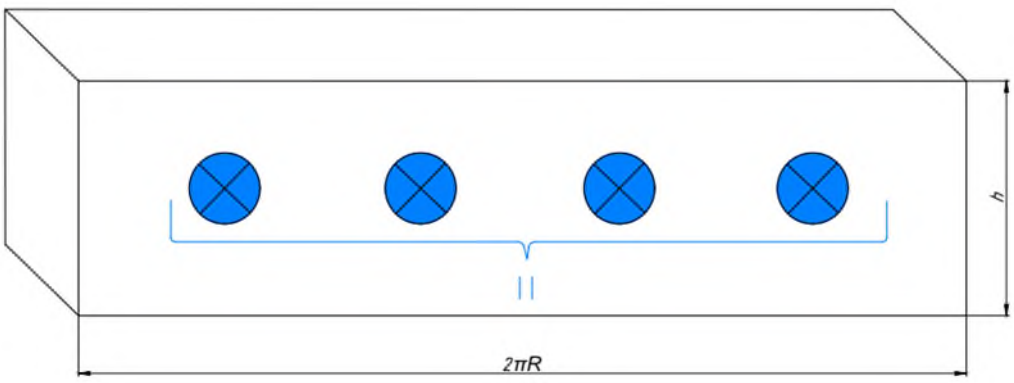

Fig.4. The location of anchor fastenings in one belt of the rising mine working.

The density of anchors per unit area is determined as follows:

$$\rho_{CT,2} = \frac{N_2}{m_2 h}, \quad \frac{штук}{м^2} \qquad (4)$$

from formula (3) has,

$$\frac{2\xi k_z \gamma_c bcos\varphi}{P_{z.ст}} = \frac{N_2}{m_2 h}$$

those. taking into account (4) for the density $\rho_{CT,2}$ we get the following formula:

$$\rho_{CT,2} = \frac{2\xi k_z \gamma_c bcos\varphi}{P_{z.ст}}, \quad \frac{штук}{м^2} \qquad (5)$$

Analysis of the results

Similarly, for the installation density of anchors along the width of the section, we use formula (5), i.e. installation density along the length and width of the section are determined by the same expression. The last formula differs from the known similar expressions for density by the presence of a term that takes into account the influence of rock pressure and a factor cosφ that takes into account the influence of bedding of host rocks.

Conclusions

Anchor support has great economic advantages compared to conventional types of support. Savings are mainly achieved by reducing the cost of fastening materials, delivery and erection of lining and by reducing the cost of excavation and transportation of rock mass. The use of anchors in combination with other types of lining also gives a significant economic effect.

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