TYPES PASSPORTS FOR ROOFBOLTING FOR CROSSES ON BROAD ROADS WITH HYDRAULIC TILTING FRICTION ANCHORS IN THE CONDITION OF THE MINE „KOSHAVA“, „GYPSUM“, JSC

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ABSTRACT. As a result of studies and expert evaluations carried out of different types anchors been preferred the hydraucally expending anchor is selected as the preferred in mine conditions for Koshava. Based on this anchor have been proposed, analyzed and investigated different schemes of passports for roofbolting the crosses of the main mine workings. As finally results was suggested four types passports linked to the specific geomechanical mining conditions.

Keywords: rock bolting, geomechanical condition, gypsum

ТИПОВИ ПАСПОРТИ ЗА ЗАКРЕПВАНЕ НА КРЪСТОВЕ НА КАПИТАЛНИ ИЗРАБОТКИ С ХИДРАВЛИЧНО РАЗПЪВАЩ СЕ ФРИКЦИОНЕН АНКЕР ЗА УСЛОВИЯТА НА МИНА „КОШАВА“, “ГИПС“ АД

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РЕЗЮМЕ. В резултат от извършени изследвания и експертни оценки на различни типове анкери в условията на мина „Кошава“, като предпочитан за основен крепежен елемент е избран хидравлично разпъващият се фрикционен анкер. На базата на този анкер са предложени, изследвани и анализирани различни схеми на паспорти за крепене на кръстовете на главните минни изработки. Като краен резултат са предложени четири типови паспорта на крепене обвързани с конкретното геомеханично състояние на масива около кръстовете.

Ключови думи: анкери, геомеханични условия, гипс

Passports for fastening the crosses of the capital constructions in the conditions of the Koshava mine

For the conditions of the mine, two standard passports have been developed and applied for fastening the crosses of the capital mines (Stoyanchev and Dermendzhiev, 2019).

The applied calculation scheme for determining the expected rock pressure is based on the hypothesis in which a peeling plate with a thickness of about 1.1 m is formed in the ceiling of the workpiece over time. This plate is sewn to the rest of the sturdy top with „Koshava“ anchors. The volume and weight of this detached part also form the expected rock pressure. According to the calculated rock scale, the scheme of placement of the anchors in the ceiling and the fastening passport is formed.

The anchors used in the type passports consist of a plastic anchor and an anchor steel rod 1.2 m long and 16 mm in diameter. They are accompanied by a rectangular plate with dimensions 100x100x10 mm. The anchors have a density of 0.69 pcs / m^2. The available scheme is square with a distance between the anchors of 1.2 m. The distance between the anchors is determined on the basis of the expected bearing capacity of the anchor from 25 to 30 KN.

The application of this type passport is for relatively strong and stable tops without expected peeling and destruction of the top. For strong tops but with expected partial delamination of the top, another standard scheme of fastening passport is applied.

This scheme has the same elements and parameters of the anchor network as in the first scheme, but also includes the undertaken network-garden type. The application of this passport is for relatively strong tops but with expected partial delamination of the top.

Both passports ensure a stable condition of the crosses of the capital works in the mine. Their application is based on a detailed assessment of the mining-geological and mining-technical conditions and the behavior of the massif in the cross.

New anchor fasteners

In the period October 2018, February 2019 in the conditions of the Koshava mine a wide study of the behavior and bearing capacity of different types of friction anchors was conducted (Stoyanchev and Dermendzhiev, 2019). Based on the results of these studies (Stoyanchev and Dermendzhiev, 2019; Design of a standard passport…, 2019; Dermendzhiev and Stoyanchev, 2019), it was decided for the conditions of the mine to develop new standard passports for fastening the

crosses of the capital works. The best-performing hydraulically extensible friction anchor "HR" should be used as the basis of standard passports.

For the development of different variants of passports for fastening with a hydraulically extensible friction anchor, specialized model studies were made on the interaction of the array with the anchor fastening systems and the expected condition of the crosses. The research systems were performed on the basis of average for the mine mining-geological and mining-technical conditions and physical-mechanical properties of the gypsum layer, as an accommodating array of capital mining.

The gypsum layer includes different types of gypsum. Its thickness is in the range, 25.0 to 29.0 m. Classification tests of the gypsum layer according to the international standard have not been performed. The data obtained in 1989 presented in Table 1 can be considered as the most reliable. The strength of uniaxial pressure σ_{UCS} varies from 14 to 17 MPa. The tensile strength σt from 1.3 to 1.5 MPa.

The depth of development is Haver. = 300 m, at average volume weight of the weaker rocks γaver. = 22,5 kN / m^3. The average strength of the gypsum layer at uniaxial pressure is 15 MPa. The coefficient of structural weakening is Kstr.≈0.5, and the angle of internal friction, φ≈45 °.

The deformation parameters of the gypsum massif are characterized by:

Dynamic modulus of elasticity, Ed≈15 - 35 GPa;

Poisson's ratio, μ≈0.3 - 0.35;

Modulus of elasticity E≈13.5 GPa.

The average volume weight of the gypsum layer varies in the range γaver.≈22 - 23 KN / m^3, average γaver.≈22.1 KN / m^3.

The main top is about 14.5 m and is made of clays, marls of clay limestones with a volume weight of about 22 kN / m^3. The upper part is made of light gray clay with a thickness of about 5 m. immediately below it is a gypsum with clay solder with a thickness of 2.5 m.

Table 1. *Strength characteristics of the gypsum layer*

№ in order	***Type of gypsum***	***Uniaxial compressive strength σucs, MPa***	***Uniaxial tensile strength σt, MPa***	***Ratio σucs/ σt***
1	*Shell gypsum*	*14,32*	*1,30*	*11,03*
2	*Layer gypsum*	*16,75*	*1,36*	*12,22*
3	*Medium to wholesale layer gypsum*	*14,77*	*1,39*	*10,66*
4	*Medium layer gypsum*	*14,81*	*1,45*	*10,18*
5	*Marl in the bottom*	*2,88*	*0,92*	*2,26*

➢ *The fastening system is based on friction hydraulically extending anchors "HR" with the following characteristics:*

1. Load-bearing capacity - 50 KN;
2. Length of the anchor - 1.5 m;

➢ *Anchor tube thickness δ = 3.2 mm, diameter ф = 42 mm; anchor The fastening system is based on friction hydraulically extending anchors "HR" with the following characteristics:*

3. Load-bearing capacity - 50 KN;
4. Length of the anchor - 1.5 m;
5. Anchor tube thickness δ = 3.2 mm, diameter ф = 42 mm; anchor hole 45 mm;
6. The cross-sectional area of the anchor pipe is 235 mm2;
7. Modulus of elasticity of steel 80 000 MPa;
8. Bound Strength - 40 kN / m or (45). Limit tensile strength;
9. Out of plane Spacing - 1.5 m (distance between anchors);
10. Bound Shear Stiffnes - 38 - 40 kN / mm (cut-off force).

Preliminary studies have found that it is very difficult to form a calculation scheme to determine the load-bearing capacity and parameters of a combined fastening with anchors. The tested anchors of the "Koshava" type have a bearing capacity of 2.5 t - 3.0 t (axial force) but do not work in a system that ensures the overall stability and safety of the upper waist in case of possible stratification of the upper.

In the first variant of anchor fastening systems with "HR" anchors, the anchors are mounted with a bearing plate independently without connecting them with grips.

The anchors are at a distance of 1.0 m from the wall, and the distance between them is 1.5 m. The total number of anchors in the proposed scheme is 31 anchors, of which 24 outside the intersection and 9 inside the intersection. In fig. 1 shows the scheme of disposal of the “HR” anchors on the ceiling of the capital construction.

➢ The second considered fastening system consists of a combined fastening - hydraulically extending anchors "HR" and connecting grips. The grips are metal rails supported by the anchors at both ends by means of planks. The software of the Canadian company Rocscience was used for the research for geomechanical analysis of the proposed variants of fastening passports. The studied parameters through the analysis are mainly acting pressure (vertical) stress - σ_1 in the waist ceiling and coefficient of stability (factor of safety) $K_{stab.}$ on the massif around the waist.

Phase^2 software ver. 9.0 makes it possible to study various fastening structures, as well as to study the condition of mine workings in unattached massifs. The main stages in the formation of the crossroads and the change in the state of the massif (σij, $K_{stab.}$) In the formation of the crossroads are studied.

The analysis of the visual results from the research of the crosses of the capital works shows the following:

In the ceiling of the crosses of the unmounted work, pressure stresses with a value of 1.0 to 1.5 MPa occur. In the corners, the values are larger, but cover larger areas of the array. When fastened, the values of the normal voltage decrease below the above values, and the safety factor of the array increases from 1.0 to 1.5 and more. In general, in the case of loose and anchored construction, the values of the normal stress are less than the compressive strength of the gypsum mass, it is stable and the coefficient of resistance is from 1.0 to 1.3. This shows that the top of the crosses is stable

at the time of construction, as well as after fastening with anchors.

When carrying out the workings - development of the waist in area and length, changes occur both in the size and the area of influence of the main normal voltage and in terms of the coefficient of resistance. The main stress increases from 1.0 to 2.6 MPa in height from 1.5 to 1.6 m in the top. The coefficient of resistance is different in different fastening systems. In the case of anchor fasteners of the first type, without grips, only with plates, the influence of the fasteners on the normal stress and stability is represented by Kstab. is insignificant. In the presence of grips and connection of anchors in the fastening system, the influence of the fasteners on the stresses and their distribution by area and height is positive, and the stability of the fastening-array system is significantly better, Kstab. 2-2.5.

Based on these main results and conclusions, we propose to apply in the crosses of the Koshava mine a fastening system of a hydraulically extending anchor "HR" in combination with grips (metal rail), plates and, if necessary, to use a net.

The realization of the bearing functions of the anchor fastening in the conditions of the mine is expected to take place in time, during the development of the deformation process, delamination and less frequent destruction of the top.

With these expectations, we recommend that the hydraulically extending anchors be 1.5 and 2.0 m long, depending on their position in a cross area.

Model schemes for passports for securing capital works in the conditions of Koshava mine

Based on the analyzed models for geomechanical condition of the crosses of the capital works, it was found that the applied type of anchor "Koshava", as well as other types of anchors in a network with a distance between the anchors more than 0.5 m does not achieve the desired support effect do not work as a fastening system. Therefore, in the future system based on anchors, it is necessary to connect them by means of techniques and form on this basis a fastening system. Based on this scheme, 7 different models of anchor fastening systems are considered, which are used to ensure the stability and safety of the crosses in the mine.

Six of the schemes use “HR” type anchors with a length of 1.5 m, located in a square mesh of 1.5x1.5 m. The differences in the schemes are in the presence of anchoring elements and the type of these elements (approaches, self-tensioning plates, different types of nets), (Design of a standard passport…, 2019).

In the seventh scheme, the distance between the anchors is 1.2 m, as in the passports of the mine. The anchor elements are taken in rows as in schemes 5 and 6 (Design of a standard passport…, 2019). In addition to grips, a garden net used by the anchor plates is also used.

This scheme is designed for complex geomechanical conditions with expected peeling of the top and collapse over time.

During the discussion of the options, the conditions under which the expected stability and security of the fixed space should be applied were assessed. The possibility of applying anchors of different lengths is not excluded. The schemes can be combined with anchors with a length of 1.5, 2.0 and more meters.

Discussion of model schemes and proposals for type passports

The developed model schemes differ from the ones applied in the mine by the type of the applied anchor. The hydraulically extending anchor has a higher bearing capacity /60-70kN/ and has certain technological advantages (Design of a standard passport…, 2019; Dermendzhiev and Stoyanchev, 2019). The use of this type of anchor makes it possible to reduce the number and density of anchors at the same expected rock pressure. Therefore, it was decided to dilute the anchor net to 1.5x1.5 m. This dilution maintains larger areas over which the anchor does not have a large impact. Therefore, the anchor nets must have approaches, through which an anchor fastening system is formed, which will provide the necessary bearing capacity and safety in case of different behavior of the array from the top.

When discussing the expected behavior of the array in the crosses of the capital works, four types of geomechanical conditions were formulated, such as:

Slight / №1 /, Sturdy resistant massifs in the top without expected stratification of the layered layers and subsequent destruction;

Medium / №2 /, Medium strong, but steadily layered massifs with expected exfoliation on planes of stratification in time;

Heavy / №3 /, Medium resistant to unstable layered massifs with expected exfoliation on planes of stratification and self-collapse in time;

Very heavy / №4 /, Unstable layered massifs with expected destruction and exfoliation on planes of stratification and self-collapse in time. Expected increase in the height of the peeling arch.

Based on the standard conditions formulated above, it was decided to design four standard passports for fastening the crosses. The passports should be based on the hydraulically extending “HR” anchor (Stoyanchev and Dermendzhiev, 2019; Dermendzhiev and Stoyanchev, 2019). Depending on the assessment and conditions, the anchors should be 1.5 and 2.0 m long. For geomechanical conditions №4, the length of the anchors is assumed to be 2.0 m.

The proposed solutions for standard passports for fastening crosses in the capital mining works of the Koshava mine for the different type of mining geological and mining technical conditions are presented in more detail in Design of a standard passport…, 2019, Annexes №1-№3.

The analysis of the expected behavior of the array from the production ceiling and the technological capabilities of the passport using busbar grips connecting the anchors shows the following: the installation of the anchors connected to the rails is labor intensive due to the standard sizes of the rails and the distances between the anchors; when interconnecting the anchors with rails, it is necessary to perform disassembly and assembly works. This will slow down the fastening operations and will require a longer stay of the fasteners in an unsecured space; presence of many fasteners that need to be connected; need for precise aiming and drilling of the anchor holes.

The above-mentioned shortcomings of the fasteners in the recommended passports presented in (Design of a standard passport…, 2019) led to the decision to replace the connecting plates with a special type of steel mesh with increased load-bearing capacity.

Under the first type of geomechanical conditions, the parameters of the anchor network are preserved using a "reinforced hexagonal mesh" as a connecting element. Under the second type of conditions, a lighter type of electric welded mesh is used as the connecting anchor unit. In the third type of "heavy" conditions, the connecting anchor unit is a heavier type of electric welded network. Under very severe conditions, the length of the anchors is 2.0 m and the distance between them is 1.2 m. The connection between the anchors is with an electrowelded mesh.

The general scheme of the type passports and the characteristic fastening parameters are given in Fig.1. The parameters of the type passports and the geomechanical conditions for their application are given in Table №2.

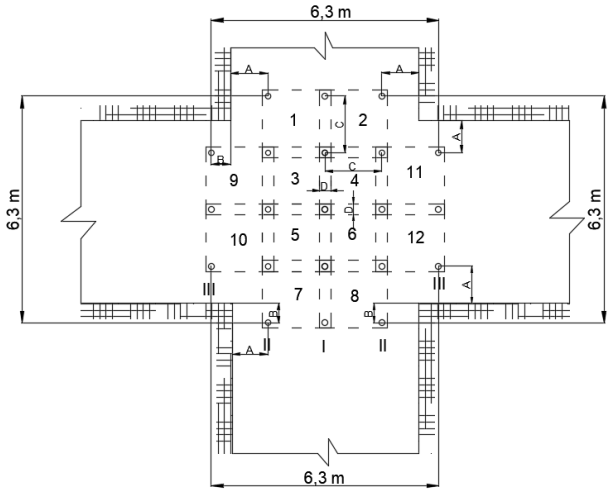

Fig. 1. General scheme of the type passports and the characteristic fastening parameters

Table 2. *Parameters of the type passports and the geomechanical conditions for their application*

Typical conditions and parameters of the passport	**Types of passports**			
	№1	№2	№3	№4
Geomechanical type conditions	Slight /№1/	Medium /№2/	Heavy /№3 /	Very heavy /№4/
Anchor type	HR	HR	HR	HR
Anchor length, m	1,5/2,0	1,5/2,0	1,5/2,0	2,0
Parameters available on the anchors, m :A B C Overlap D	1,0 0,5 1,5 0,15	1,0 0,5 1,5 0,15	1,0 0,5 1,5 0,10	1,0 0,2 1,2 0,10
Plank, dimensions m x m	0,15 x 0,15	0,15 x 0,15	0,15 x 0,15	0,15 x 0,15

Mesh, type	**Hexagonal**	**Electrowelded**		
Canvas dimensions mech m x m	1,7 x 6,5	1,7 x 1,7	1,7 x 1,7	1,5 x 1,5
Mesh dimensions: Diameter of bodies, mm Dimensions of the holes, m x m	 3,0 0,1 x 0,1	 4,0 0,15 x 0,15	 5,0 0,1 x 0,1	 5,0 0,1 x 0,1

Conclusions

When sizing the anchor fasteners according to the so-called "set load" scheme and its placement in a network with a distance between the anchors of 0.8-1.0 m, the anchors do not work as a system and do not have a stabilizing effect on the fixed array. In these cases, regardless of the load-bearing capacity of the anchors used, they must be connected in a network by the use of various connecting units, such as grips, plates and nets. In this way, the fastener is formed as a system that provides the necessary load-bearing capacity and security of the fixed space.

The proposed standard passports for fastening the crosses of the capital constructions of the Koshava mine, developed on the basis of the hydraulically extending friction anchor / HR / and the additional connecting additional elements, create a real opportunity to ensure high stability and safety of the crosses in different mining and technical conditions.

The standard fastening passports are to be applied and adapted in the conditions of the mine.

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