Research of the parameters of contour blasting in the construction of underground mining works in fast rocks

Yunus Norov, Yokub Karimov, Zuhriddin Latipov, Amirjon Khujakulov and Najmiddin Boymurodov
Karshi Engineering Economic Institute, 180100, Karshi, Uzbekistan

E-mail: Zuhriddin.Latipov@mail.ru

Abstract. The article develops a methodology for studying the parameters of contour blasting during the construction of underground mine workings in hard rocks. Research has established the effect of the distance between the contour holes and the influence of the values of the coefficient of approximation on the efficiency of contour blasting.

1. Introduction
The separation of rocks from the massif during the construction of underground mine workings in hard rocks is carried out mainly by an explosive method. The efficiency of drilling and blasting operations is assessed by the value of the utilization rate of the borehole, the uniformity of crushing of the blasted rock, as well as other indicators.

An important indicator of the quality of drilling and blasting operations is the accuracy of the roadway contouring. However, until recently, they tried, mainly, not to allow a reduction in the design section of the mine, in order to avoid additional work on its delineation. With regard to the surplus of the removed rock, although there are certain norms, they, as a rule, are not kept. At the same time, exceeding the design cross-section also requires additional work on loading the excessively excavated rock, filling the unsecured space and filling this space with concrete or mortar during the construction of a long-term engineering structure, which increases the cost and reduces the pace of work.

Simultaneously with the useful work of the explosion to separate the massif and crush the rocks, the side rocks also undergo partial destruction, expressed in an increase in fracturing, delaminating of rock falls, etc. This entails a loss of outcrop stability, an increase in rock pressure, the need to install reinforced support, which in turn increases the cost of work.

The reasons for the unsatisfactory delineation of workings are both, to a certain extent, a low culture of drilling and blasting operations at the relevant enterprises, and the generally accepted technology for conducting these works, which makes it inevitable that a significant curvature of the required surface and the receipt of excess rock to be removed.

Recently, many studies have been carried out, which have shown the possibility of a more accurate delineation of workings during blasting operations and are called contour blasting. The difficulty of solving the issues of the drilling and blasting complex on the working contour lies in the fact that its main parameters, i.e. the distance between the contour boreholes, the loading factor, the convergence factor of the charges and the sequence of blasting are interrelated, and a change in one of them affects all the others.

A number of researchers solve this issue in a comprehensive manner, linking the main parameters with each other, others approach the choice of individual parameters independently of the others, thus
introducing misinterpretation in the solution of the issue. In addition, the research carried out refers to the workings of a small section, and the question of determining the parameters of contour blasting during the construction of mine workings of a large section in rocks of various strengths has hardly been studied and has no solution.

On the basis of the foregoing, the scientific task of developing the parameters of contour blasting during the construction of large-section mine workings in hard rocks is formulated, which is of great importance for the science and practice of mining.

2. Methods
When conducting research, complex methods are used, including theoretical generalizations and experimental studies in the laboratory, polygon and industrial conditions, methods of mathematical modeling of contour blasting parameters during the construction of mine workings in hard rocks, mathematical programming methods using modern computer technology, as well as methods of mathematical and correlation analysis of research results.

A technique has been developed that provides for experiments to determine the main serial methods of using the method in several characteristic structural-geological conditions during the construction of mine workings. The technique provides for the implementation of group experiments, which has the goal of empirically defining drilling and blasting operations on the development contour for further graphic-analytical processing of the results obtained.

Experimental work involves the following factors.
Group 1 - the influence between the boreholes in the development contour on the rock surges.
Group 2 - the influence of the convergence coefficient in the working contour on the overburden.
Group 3 - the influence of explosive blasting and the efficiency of explosives for circuit charges, the charging factor and the design of the charge on overshoots and disturbances in the structure of the working outlines.
Group 4 - the influence of the order of detonation and the detonator deceleration time in contour charges on the quality of the roofing of workings.
Group 5 - the influence of the angle of inclination of the contour boreholes on the approaching charge method.
Group 6 - the influence of structural and geological conditions on the method of the method.

The final evaluation of the results of experiments to determine the quality indicators of the observation contour by surveying the magnitude of overshoots, as well as by surveying the magnitude of overshoots.

In some cases, the inspection of the disturbed zone was carried out by the ultrasonic method to achieve comparative characteristics of the explosion action with the usual method of work and with the use of contour blasting technology. All experiments with a borehole length of 2.6-4.0 m and a diameter of 42 mm.

3. Results and Discussion
As the studies of various authors [1-22], as well as the experience of using the contour blasting technology show, the effectiveness of the method, depends on the correct choice of the distance between the contour holes (a) the value of the approach coefficient Ksb (the ratio of the distance between the contour holes to the line of least resistance (LLS) to the pre-contour row of holes) and the charging factor K3 (the size of the charge to the volume of the hole containing it). The correct choice of these parameters for specific structural-geological conditions makes it possible to transfer an array of explosion energy sufficient for breaking off the rock along the contour line without significant damage to the contour massif during the explosion of charges in contour boreholes.
The first stage of experiments, aimed at determining the optimal distance between the contour boreholes, was carried out in low-fractured sandstones with insignificant siltstone interlayer's. Strength coefficient on the scale of Prof. M.M. Protodyakonov $f = 9$, the ultimate compressive strength of rocks is 840-960 kg/sm$^2$.

Before starting work, taking into account the available assortment of explosives and explosives, a charge for contour boreholes was designed (Fig. 1), consisting of 5 cartridges fixed on a reference bar at a distance of 10 cm from each other. A detonating cord thread was laid along the charge to transfer detonation between the cartridges.

Before the start of the experiment, five charges of the described design were tested for completeness of detonation at the base explosive storage site. Initiation was carried out with delayed action detonators (deceleration time 0.5 s) from a KPM-1 explosive machine. All charges exploded completely.

The first experiments were carried out on a special contour pillar with a thickness of about 1 m, which was left along the sides of the mine after the explosion, the experimental scheme is shown in Fig. 2.

**Figure 1.** The design of a loop charge with inert spacers and DC

The first stage of experiments, aimed at determining the optimal distance between the contour boreholes, was carried out in low-fractured sandstones with insignificant siltstone interlayer’s. Strength coefficient on the scale of Prof. M.M. Protodyakonov $f = 9$, the ultimate compressive strength of rocks is 840-960 kg/sm$^2$.

Before starting work, taking into account the available assortment of explosives and explosives, a charge for contour boreholes was designed (Fig. 1), consisting of 5 cartridges fixed on a reference bar at a distance of 10 cm from each other. A detonating cord thread was laid along the charge to transfer detonation between the cartridges.

Before the start of the experiment, five charges of the described design were tested for completeness of detonation at the base explosive storage site. Initiation was carried out with delayed action detonators (deceleration time 0.5 s) from a KPM-1 explosive machine. All charges exploded completely.

The first experiments were carried out on a special contour pillar with a thickness of about 1 m, which was left along the sides of the mine after the explosion, the experimental scheme is shown in Fig. 2.
In this pillar, contour boreholes were drilled at a distance of 50, 60, 70, 80, 90, 100 cm from each other. Charging and detonation of charges in these boreholes were carried out after the explosion of charges of the main certificate of drilling and blasting operations in order to eliminate the effect of clamping on the action of contour charges. All circuit charges were equipped with 0.25 s short-time detonators and detonated simultaneously. The experimental results are shown in Table 1.

Table 1.

| Distance between contour holes, sm | Circuit state after the explosion |
|------------------------------------|----------------------------------|
| 50                                 | There are no hole marks. The location of the contour charge is represented by the disturbed zone, bust ≈15 sm. |
| 60                                 | Not clear traces of holes. Significant fracturing of the massif at the location of the charges and in the longitudinal gap between the holes. Overkill 10 sm |
| 70                                 | Well-defined borehole marks. Weakly noticeable fracturing along the borehole track. Front rear sight without visible violations. Bust 8-10 sm. |
| 80                                 | Clear traces of holes without visible disturbances of the array from the action of a contour charge, overshoot is not marked |
| 90                                 | Clear traces of holes without visible disturbance of the massif from the explosion. Increase in protrusions on the rock gap between the holes. The weak shortfall in production profile. |
| 100                                | Clear traces of holes. The location is charged with longitudinal projections. Shortage of 10 sm, glasses in the holes. |
From table 1 it can be seen that the greatest approximation of the working to the design outline was obtained at $\alpha = 80-90$ sm. When $\alpha > 90$ sm, there was a shortage of rock: this is explained by the fact that the force of the explosion of charges of two adjacent holes becomes insufficient to resolve the rock gap between them. At $\alpha < 80$ sm, the impact of the force of the explosion of charges of two adjacent boreholes on the front pillar between them cause not only destruction but also a violation of the out-of-the-way rock mass, i.e. there are rock surges along with the mine profile.

In support of the latter assumption, it should be noted that in subsequent experiments, with a deliberate approach of 3-4 boreholes up to 30-40 sm, due to an increased concentration of explosives on a short section of the roof, not only an overrun occurs, but in some cases, there was an ejection from a neighboring borehole of explosives and blast it in the air.

Thus, the smallest deviation from the design contour during the explosion was obtained at a value of $\alpha$ in the range from 70 to 90 sm, which made it possible to further lay these values in the operating ports of drilling and blasting operations for this development.

In order to reduce poor-quality drilling and blasting operations on the results of contour blasting, optimal drilling and blasting passport has been developed for the drilling equipment used (Fig. 3).

The calculation determined the following parameters of the passport: the number of holes - 79; cut a combined vertical wedge with a pyramid, specific consumption of explosives 1.3 kg/m3; specific consumption of drilling 1.6 m/m3, advance per explosion - 2 m. Nobelite was used as explosive, electric blasting according to a sequential scheme using a KPM-1 blasting machine. The distance between the contour holes is 70, 80, 90 sm, with a corresponding change in the number of contour holes. In a number of cases, with poor-quality drilling, the value of $\alpha$ was 65, 75, 85, as well as 100 and 110 sm. When working out the results of explosions, the values of $\alpha = 65, 75, 85$ sm were taken into account, and 100 and 110 sm were excluded as random. The results of the described cycle are shown in Fig. 4.

In accordance with the methodology of experimental work, in the process of conducting experimental explosions, nobelite in contour charges was replaced by another type of explosive with the same charge design. The replacement was carried out in order to determine the influence of the explosive power on the distance between the contour holes.
Figure 3. Passport of drilling and blasting operations for the period of experiments

Figure 4. Dependence of the overshoot value on the distance between the contour boreholes for the rock with $f = 9$
Most of the experiments to determine the optimal distance between the contour boreholes were set to a distribution system in rocks with $f = 8$. The optimal value was determined for the following rocks: sandstones with siltstone interlayer’s, hard limestone’s on calcite cement and limestone’s with clay inclusions. Comparison of the experimental results showed that the value for all rocks with $f = 6$ has a true value (within the measurement accuracy - 5 cm). In all experimental explosions, a nobelite contour charge was used. In fig. 5 shows a graph of the dependence of the magnitude of the search for rocks with $f = 8$. It can be seen from the graph that the smallest deviation of the working from the design outline takes place $a = 90$-$100$ sm. boreholes, a significant violation of the roof, accompanied by busting up to 18-20 sm and stabbing of the rock at the location of the contour charges, which required a particularly careful assembly of the roof and walls of the mine.

![Figure 5. Dependence of the overshoot value on the distance between the contour boreholes for rocks with $f = 8$](image)

With an increase of $a > 90$ sm, the size of the rock protrusions in the rock gap between the boreholes increased, followed by a general shortage along with the mine profile (20-25 sm). With a sharp increase up to 120-130 sm, the contour charges, as a rule, were “shot through”, leaving significant deficiencies that are difficult to develop.

In fig. 6 shows the dependence of the magnitude of the search on the distance between the contour boreholes for rocks with a strength coefficient $f = 10-11$. 


Figure 6. Dependence of the values on the distance between the contour holes for the rock with $f = 10-11$

The graph shows that the smallest distance between holes should be set within the above-average strength. According to the schedule, the specified strength factor is set to the maximum value in order to reduce the drilling rate for contour holes. At the same time, the grade of explosives is selected for the contour holes, the most effective for the given conditions. The upper part of the curves for nобильite in cartridges with a diameter of 20 mm is given roughly (dashed line) due to the sufficient amount of experimental data for construction in hard rocks and requires additional verification. It should be noted that the values selected according to one of the curves are optimal for tight, low-fractured rocks. If there are violations in the array, it is corrected (usually downward).

Data processing of experimental explosions was carried out according to the least-squares method. The change interval between the contour boreholes is 5 sm, and therefore the number of actual values $a$ is rounded to the required accuracy.

The practice of using contour blasting [15-26] shows that the magnitude of the approach coefficient ($K_{sb}$), i.e. $a/W_k$ affects the impact of overburden and the height of the rock ledges after the explosion. Thus, a search is provided with a known optimal distance between the contour boreholes with the value of $W_k$ in order to build a certificate for drilling and blasting operations.

The work was carried out in 2 stages. In the first period, the dependence of the overruns value on the $K_{sb}$ value in rocks with $f = 3$ was checked. In the second period, based on the previous data obtained as a result of the introduction of the contour blasting technology, the dependence of the $K_{sb}$ value on the strength was revealed.

The first period of research was carried out in the bottom hole with a cross-section of 67 m² (in tight cracks ($f = 6$), disturbed by insignificant production of tectonic cracks.

Experimental conditions: $a = 100$ sm, loop charge circuit - with DS gaskets. During the experiments, at a constant value of $W_k$, the following values were artificially set: 80; 90; 110; 120; 130 sm, i.e. the value of $K_{sb}$ approach, respectively, constituting 1.25, 1.10, 0.91, 0.83, 0.77.
In fig. 7 shows a graph of the magnitude of overruns from the value of Ksb at a constant value of f. It can be seen from the graph that in weakly fractured sandstones the smallest deviation of the working profile from the design outline took place at Ksb = 1. When Ksb > 1, undershoot occurs, and when Ksb < 1 - overshoots.

![Graph of the dependence of the amount of overshoot on the value of Ksb at a constant value of f](image)

**Figure 7.** The graph of the dependence of the amount of overshoot on the value of Ksb at a constant value of f

Thus, the influence of $K_{sb}$ on the influence of brute-force identification on this influence. However, it should be noted that the curve of the dependence of the overshoot value on $K_{sb}$ is steeper, i.e. this value is indicative in assessing the explosion effect from the point of overshoot.

Analysis of the optimal value from the point of view of the action of blast waves on the basis of the contour of sight between the contour boreholes suggests that with the simultaneous explosion of contour charges in two adjacent boreholes to obtain a spall along the contour line, the travel time of the blast waves to the exposed plane be greater than the travel time $\frac{1}{2}$ the distance between the contour holes, i.e. at a constant velocity of propagation of blast waves $W_k > \frac{a}{2}$.

However, the presence of a spread in the response time of circuit charges detonators can lead to an increase in the path of the blast wave between the circuit holes to a value. Then the possible reason for the destruction of the gap between the contour boreholes can be written as: $W_c > a$. Or, replacing $a/W_k$ with $K_{sb}$, we have $K_{sb} < 1$.

In fig. 8 shows a graph of the dependence of the optimal Ksb value on the rock strength. As can be seen from the graph, a smaller value of the investigated coefficient corresponds to rocks of a large strength and vice versa. This can be explained by a decrease in the value of an included in this coefficient, which increases the force of the rock.
Figure 8. Dependence of the $K_{sb}$ value on the rock hardness

The graph also shows that the relationship between these two values is of a correlation in nature. The significant scatter of points shows that the overlapping of $K_{sb}$ affects many natural conditions, therefore, the use of the curve shown in the figure for design calculations is non-cellulosic. When designing a drilling certificate, a more correct value of $W_c$ can be compiled according to a table compiled on the basis of averaged data for the second corresponding category of strength (Table 2).

| Strength coefficient on the scale of Prof. M.M. Protodyakonov, $f$ | 6-7 | 8-9 | 10-12 |
|---------------------------------------------------------------|-----|-----|-------|
| Value $K_{sb}$                                               | 1.1 | 1.0 | 0.8-0.75 |

Thus, empirical dependencies have been established that allow to graphically determine the distance between the contour boreholes depending on the hardness of the rocks for different explosives, the optimal loading factor in rocks of different strengths for a number of explosives, the expected overshoot value depending on the loading factor and the strength of the depending on the detonator deceleration time in circuit charges.

4. Conclusions

1. For charges of contour boreholes with a diameter of 42 mm, different explosives of medium and low blasting capacity can be used in cartridges of standard and reduced diameter. In this case, the loading coefficient varies depending on the hardness of the rocks and the accepted distance between the holes in the range of 0.2-0.6. The use of explosives of increased brisance in boreholes with a diameter of 42 mm for contour charges is possible only in cartridges of reduced diameter, the value of which depends on the required loading coefficient.

2. The distance between contour boreholes in rocks with $f = 6$-11 for most industrial explosives should be within 70-120 sm. For this type of explosive, this distance must be reduced with an increase in the rock hardness, as well as with a decrease in the loading coefficient. The value of the borehole
approach ratio \((K_{sb} = a/W_k)\) affects the amount of overshoot, the \(K_{sb}\) values must be reduced with an increase in the rock hardness. As a rule, \(K_{sb}\) should be less than 1.

3. The design of the contour charge should be considered optimal, consisting of special explosive cartridges of reduced diameter, placed in a borehole of normal diameter. The diameter of the cartridges is assigned taking into account the required loading coefficient and the value of the critical diameter for the accepted explosive grade. The value of the charging factor \(K_3\) for this design of the charge for most industrial explosives should be taken in the range from 0.2 to 0.5.

The use of dispersed charges from standard-diameter explosive cartridges with gaskets and DC can be recommended in contour boreholes only with a small amount of work on contour blasting.

4. All circuit charges should be detonated simultaneously using detonators with a minimum spread in response time. For currently produced detonators, the maximum deceleration time should not exceed 1.5 seconds.

5. Depending on the specific structural and geological conditions, the parameters of contour blasting should be adjusted in terms of the location of the holes relative to the line of the design contour:
   - in dense, slightly fractured rocks - with the maximum approximation to this line;
   - in overhanging layers - below the line of the design contour by 10-15 cm;
   - with a thickness of rock layers less than 40 sm - below the line of the design contour by 30-40 cm.

6. As a result of the work carried out, empirical dependencies were obtained that allow graphically determining the following parameters of blasting:
   - distance between contour boreholes depending on rock hardness for different explosives;
   - the optimal loading factor in rocks of various strengths for a number of explosives;
   - the expected amount of overkill, depending on the loading coefficient and the strength of the breed;
   - the expected magnitude of overshoots depending on the detonator deceleration time in circuit charges.

References

[1] Zairov Sh.Sh., Urinov Sh.R., Ravshanova M.Kh. Ensuring the stability of the sides of open pits during blasting operations. - Monograph. - LAP LAMBERT Academic Publishing. - Germany, 2020. - 175 p.

[2] NIS Institute "Orgenergostroy". Scientific and technical report on the topic: "Participation in the improvement of certificates for drilling and blasting operations in the construction of underground facilities of the Charvak HPP." - Contract No. 1243, 2004.

[3] Ivanovsky D.S., Nasirov U.F., Zairov Sh.Sh., Urinov Sh.R. Displacement of rocks of different strength by the energy of the explosion. - Monograph. - LAP LAMBERT Academic Publishing. - Germany, 2020. - 116 p.

[4] Zairov Sh.Sh., Urinov Sh.R., Ravshanova M.Kh., Nomdorov R.U. Physical and technical assessment of the stability of the sides of the quarries, taking into account the technology of drilling and blasting operations. - Monograph. Bukhoro, publishing house "Bukhoro", 2020. - 175 p.

[5] Urinov Sh.R., Khamdamov O.O. Investigation of the process of loading rocks with detonation products during the explosion of borehole charges of explosives with various types of boreholes // Gorny Vestnik of Uzbekistan. – Navoi, 2011. - №1. - S. 77-80.

[6] Petrosov Yu.E., Makhmudov D.R., Urinov Sh.R. The physical essence of rock crushing by the explosion of explosive borehole charges // Mining Bulletin of Uzbekistan. – Navoi, 2016. - №4. - S. 97-100 (05.00.00; No. 7).

[7] Zairov Sh.Sh., Makhmudov D.R., Urinov Sh.R. Theoretical and experimental studies of explosive destruction of rocks at various forms of a clamped medium // Gorny Zhurnal. - Moscow, 2018. - No. 9. - S. 46-50.
[8] UrinovSh.R. Classification of methods of management by the direction of action of explosion trenched charges of emission in soils // Proceeding of the joint scientific seminar of winners of "Istedod" foundation of the President of the Republic of Uzbekistan and Shanghai University Scientists. Shanghai, October 2007, 47-50 p.

[9] UrinovSh.R. Researches of laws of formation lengthened digs in various soils explosions trenched charges of emission // Proceeding of the joint scientific seminar of winners of "Istedod" foundation of the President of the Republic of Uzbekistan and Shanghai University Scientists. Shanghai, October 2007, 50-55 p.

[10] Norov Yu.D., Bibik I.P., Zairov Sh.Sh., Urinov Sh.R., Nazarov ZS, Norov D.Sh. Determination of the coefficient of the protective ability of the shielding slots // Certificate of official registration of the computer program No. DGU 02325 by application No. DGU 2011 0153 dated 20.07.2011. Registered in the state register of computer programs of the Republic of Uzbekistan on 27.10.2011.

[11] Nazarov Z.S., Urinov Sh.R., Yuldashev U.U., Eshmirzaev A.A. Methods for measuring the granulometric composition of the blasted rock mass by the method of photoplanimetry and the calculation algorithm // Materials of the scientific-practical conference "Innovative technologies of the mining and metallurgical industry". - Navoi, October 21, 2011 - S. 30-33.

[12] Norov Yu.D., Zairov Sh.Sh., Urinov Sh.R. Experimental studies of the action of the explosion of a concentrated shortened borehole charge of explosives. - Science-and-file journal: Kremenchutsk national university of Mikhail Ostrogradsky. - Kremenchuk: KrNU, 2012. - Issue 1 (9). - S. 23-29.

[13] Norov Yu.D., Zairov Sh.Sh., Urinov Sh.R. Development of a methodology for calculating the effective parameters of borehole charges of explosives during contour blasting // Collection of scientific articles of the republican scientific and practical conference on the topic: "Modern problems of rational subsoil use." - Tashkent, September 26, 2013. -- S. 64-66.

[14] Ishmamatov M.R., UrinovSh.R., YuldashevSh.Y., Tursinboeva Z.U. Effect of initial concentration distribution favorable on the facade parameters // Investigations of fluid movement filtration of solutions in elastic regime of the plaster // Proceedings of the international conference on integrated innovative development of Zarafshon region: achievements, challenges and prospect. 2017 y. - p. 193-197.

[15] Urinov Sh.R. Computer modeling of mining facilities // Materials of the Republican scientific and technical conference on the topic: "Mining and metallurgical complex: problems and solutions." - Almalyk, April 8, 2015 - P. 217.

[16] Urinov Sh.R., Sattarov O.U. Design of technological processes // Materials of the Republican scientific and technical conference on the topic: "Mining and metallurgical complex: problems and solutions." - Almalyk, April 8, 2015 - P. 221.

[17] Boybutaev S.B., Urinov Sh.R., Tursinboeva Z.U. Development of a conceptual model of automation of technological processes at mining enterprises // Materials of the Republican scientific and technical conference on the topic: "Mining and metallurgical complex: problems and their solutions." - Almalyk, April 8, 2015 - P. 233.

[18] Urinov Sh.R. The choice of the parameters of the explosion of borehole explosive charges and methods of their calculation // VIII-International scientific and technical conference on the topic: "Mining and metallurgical complex: achievements, problems and modern development trends." - Navoi, November 19-21, 2015 - S. 17.

[19] Urinov Sh.R., Nazarov Z.S., Sharipov I.N. Analysis of the regularities of the outflow of detonation products from the well // VIII-International scientific and technical conference on the topic: "Mining and metallurgical complex: achievements, problems and modern development trends." - Navoi, November 19-21, 2015 - S. 25.

[20] Urinov Sh.R. Analytical researches of influence of burning part chink of charge explosive on decrease in peak pressure // VIII-International Scientific and Technical Conference on the topic:
"Mining and Metallurgical Complex: Achievements, Problems and Modern Development Trends." - Navoi, November 19-21, 2015 - S. 48.

[21] Norov Yu.D., Urinov Sh.R. Investigation of the mechanism of reduction of variety at the use of the developed design of charging in bottom wells // Materials of the IX-International Scientific and Technical Conference on the topic: "Achievements, problems and modern trends in the development of the mining and metallurgical complex." - Navoi, June 12-14, 2017 - S. 25.

[22] Urinov Sh.R. Investigation of the coefficient of the protective ability of the screening shell depending on its width and the frequency of explosion // Materials of the International Scientific and Technical Conference on the topic: "Prospects for the innovative development of the mining and metallurgical complex." - Navoi, November 22-23, 2018 - P. 22.

[23] Zhuravlev, P., Marukyan, A., Markova, I., Khidirov, S., Nazarov, B. The rationale for taking into account the organizational features of work in the winter when designing. IOP Conference Series: Materials Science and Engineering. 2020. 883(1). DOI:10.1088/1757-899X/883/1/012212.

[24] Longefors U. Slotsprangning. "Technisktideskrift" v88, №14.

[25] Kattakulov, F., Muslimov, T., Khusainov, A., Sharopov, S., Vokhidov, O., Sultanov, S. Water resource saving in irrigation networks through improving the efficiency of reinforced concrete coatings. IOP Conference Series: Materials Science and Engineering. 2020. 883. Pp. 012053. DOI:10.1088/1757-899X/883/1/012053.

[26] Longefors U. Model scale test in rock plasting. "Quarterly of the Colorado school of mines", №3.