

**Tomilov A.N., Demin V.F.,
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JUSTIFICATION OF PARAMETERS AND AUTOMATION OF CALCULATION OF ANCHOR SUPPORT OF MINING WORKINGS



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The monograph is devoted to the substantiation of parameters and development of the methodology of automated calculation of anchor fastening of mine workings. Particular attention is paid to the study of influencing mining-geological and mining-technical factors on the parameters of the support, as well as the adaptation of modern technologies of anchor fastening for the operating conditions of coal mines.

The scientific novelty of the work lies in the creation of a structural scheme for calculating the parameters of anchor fastening, identifying patterns of changes in the parameters of the support under the influence of operating conditions and developing software for automated design of the support.

The material will be useful for specialists in the field of mining, design and operation of mine workings, as well as for researchers involved in the development and implementation of innovative technologies in the mining industry.

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REGULATORY REFERENCES

This study uses references to the following standards:

GOST R 57719-2017. Mining. Mine workings. Terms and definitions. National standard of the Russian Federation: approved and put into effect by the Order of the Federal Agency for Technical Regulation and Metrology dated September 26, 2017, No. 1247-st.

GOST 12.0.002-2014. Occupational safety standards system. Terms and definitions: approved. by the Interstate Council for Standardization, Metrology and Certification on September 30, 2014, No. 70-P.

GOST R 57717-2017. Mining. Safety in coal mines. Terms and definitions. National standard of the Russian Federation: approved. put into effect by the Order of the Federal Agency for Technical Regulation and Metrology dated September 26, 2017, No. 1244-st.

GOST R 55154-2012. Mining equipment. Multifunctional coal mine safety systems. General technical requirements. National standard of the Russian Federation. Approved and put into effect by Order of the Federal Agency for Technical Regulation and Metrology dated November 22, 2012 N 1077. Moscow: Standartinform, 2014.

GOST R 58199-2018. Mining equipment. Anchor support made of polymer composites. General specifications. National standard of the Russian Federation: approved and put into effect by the Order of the Federal Agency for Technical Regulation and Metrology dated August 14, 2018, No. 494-st.

GOST 33164.1-2014. Mining equipment. Mechanized supports. Support sections. General specifications. Interstate standard.

SYMBOLS AND ABBREVIATIONS

PPGD	– manifestation of increased mountain pressure
RMPI	– development of mineral deposits
KarSTU	– Karaganda State Technical University
MATEC	– Materials Science, Engineering and Chemistry
CCIT	– Computing, Communication and Information Technolog
KKSON	– Committee for Control in the Sphere of Education and Science
MON	– Ministry of Science and Education
RK	– Republic of Kazakhstan
IVS	– information and computing systems
TOO	– limited liability partnership
GSI	– Geological Strength Index
A-III, A-IV	– class of reinforcing steel
AM	– anchor with metric thread
AVM	– screw anchor
PGD	– increased mountain pressure
AK	– rope anchor
OGD	– supporting rock pressure
JSC	– joint stock company
ATTENTION	– Interdisciplinary scientific center «Research Institute of Mining Geomechanics and Mine Surveying»
UD	– Coal Department
JSC	– Joint-stock company

The paper uses units of measurement traditional for mining engineering literature: kN, MPa, kN/m², mm,m, km, m³/h, m³/t, t, m², kg/mm², etc.

INTRODUCTION

Relevance topics. With the transition to greater depth of development in the Karaganda coal basin, the mining and geological and mining conditions have become more complicated, the sizes of the support pressure zones in the vicinity of stopes and the intensity of rock pressure manifestations in the workings inside the extraction fields have increased significantly. More than 60% of the host rocks of the immediate roof of coal seams of underground mine workings in the mines of the Karaganda coal basin are in an unstable state, and the rocks of the immediate soil are subject to swelling. In view of this, the multiplicity of re-bolting of supported workings reaches a two- to three-fold value during the service life and more than 25% of them are annually subject to repair and a set of works to increase their stability with significant material costs and labor intensity.

Anchor fastening technologies for mine workings have recently found increasing application all over the world. At the same time, in the mines of the Karaganda coal basin, the practice of its operation has revealed a number of serious shortcomings that lead to deformations of preparatory mine workings: displacement of the rock contour, collapses from the roof and sides of the workings.

The main influence on the choice and parameters of anchor fastening of mine workings is exerted by mining and geological and mining technical factors for specific operating conditions. In this regard, the task of calculating the parameters of anchor fastenings for specific operating conditions, taking into account the influencing factors for maintaining the stability of mine workings of various technological purposes, is relevant and in demand, both in the mines of the Karaganda coal basin and in the mining sector of the economy of the Republic of Kazakhstan.

The aim of the work is the substantiation of the parameters of the technology of anchor fastening of mine workings, taking into account the influencing factors of operating conditions, ensuring an increase in the profitability and safety of coal seam mining.

Idea of work consists in creating conditions for expanding the scope of application of single-, two-level, and combined anchor fastening of mine workings for various technological purposes, taking into account the influencing factors of operating conditions.

The object of the study are mine workings of various technological purposes, carried out and maintained under specific operating conditions of a mining-geological and mining-technical nature.

Scientific problem consists in substantiating the parameters of anchor fastening of mine workings, taking into account the influencing factors of operating conditions, to ensure the stability of the mine working contour.

Methodology for performing work includes:

- research and determination of factors influencing the parameters of rock bolting of mine workings, assessment of the stability of mine workings of the Karaganda basin, analysis of the designs of rock bolting and the conditions of their use in coal mines;
- conducting and analyzing in-kind observations of rock mass displacements near mine workings in the Karaganda coal basin;
- development of a methodology and structural diagram for selecting the type and calculating the parameters of single-level, combined, two-level anchor technology for supporting mine workings, adaptive to the influencing factors of coal mine operating conditions;
- development of a methodology for the automated calculation of parameters of anchor technology for supporting mine workings of various technological purposes, relevant to the operating conditions of mines in the Karaganda coal basin and implemented in the format of a computer program;
- development of technical solutions for the selection of the type and calculation of the parameters of the fastening of mine workings using anchor fastening technology for specific operating conditions of mines in the Karaganda coal basin;
- justification of the choice of anchor fastening of underground mine workings based on the cost factor;
- establishing patterns of change in anchor fastening parameters from influencing factors of operating conditions of coal mine workings.

The solution of the set tasks is carried out by the method of analysis of domestic and foreign experience in the field of calculation and application of parameters of anchor technology for fastening of mine workings, taking into account a set of influencing factors, natural observations, mathematical and computer substantiation of parameters of anchor fastening of mine workings, testing of results in industrial conditions of operation of mines of the Karaganda coal basin.

Scientific novelty consists of:

- a structural diagram of the justification and calculation of the parameters of anchor fastening of mine workings, carried out in the massif and supported outside the zone, in the zone of influence of cleaning works, protected behind the longwall entirely, extinguished behind the longwall, allowing to expand the scope of application of the technology of anchor fastening of mine workings in coal mines;
- patterns of change in the parameters of anchor fastening of mine workings depending on the depth of the mine, the width of the workings, the resistance of roof rocks to compression for the mines of the Karaganda basin, allowing the selection and creation of a justified version of the type of anchor fastening technology;
- a program for calculating the parameters of anchor fastening of mine workings for various technological purposes, adaptive to specific operating conditions of coal basin mines, allowing for an increase in the productivity and efficiency of the work of technological services of mines when developing a scheme and passport for the conduct of mine workings.

Scientific significance. The work consists of substantiating the parameters and calculation methodology for the technology of anchor fastening of preparatory mine workings, taking into account the influencing factors of operating conditions.

Practical value. The work consists of:

- in the selection of the scheme and methodology for calculating the parameters of anchor fastening of mine workings in the Karaganda coal basin;
- in substantiating the choice of technology for anchor fastening of mine workings of various technological purposes for specific operating conditions of mines of the Karaganda coal basin;
- in the patterns of change in the parameters of anchor fastening technology from the influencing factors of the operating conditions of mine workings. The patterns will allow the technological services of mines to model the parameters of fastening of mine workings and select justified options for types of anchor fastening;
- in the development of a computer program for automated calculation of anchor fastening parameters.

The main scientific provisions submitted for defense:

- methodology for calculating the parameters of single-, two-level, and combined anchor fastening of mine workings, based on the the-

ory of a load-bearing bridge and suspension to stable rocks, which will ensure the stability of the marginal rock mass;

- patterns of change in the parameters of anchor fastening of mine workings depending on the depth of the mine workings, the width of the workings, the resistance of the roof rocks to compression, which will allow creating technological schemes and a passport for the implementation of mine workings.

The validity and reliability of scientific provisions, conclusions and recommendations are confirmed by: correct formulation of technological problems and the legitimacy of using modern computational methods to solve them; satisfactory convergence of the results of theoretical studies with actual data from industrial observations.

Lauthors' personal contribution consists in conducting both theoretical and field studies aimed at achieving the research objective, in preparing a monograph on the research topic. The authors have developed a methodology for calculating the parameters of anchor fastening of development mine workings for the operating conditions of the Karaganda coal basin mines; a methodology for automated calculation of anchor fastening parameters. Also, technical solutions have been developed to justify the parameters of anchor fastening of mine workings of various technological purposes for the mines of the Karaganda coal basin, taking into account the influencing factors of the mining and geological and mining-technical nature of the basin's mines, and patterns of change in anchor fastening parameters from the influencing factors of operating conditions have been identified.

Testing the work. The main provisions of the work were reported and approved: at scientific seminars of the RMPI department of KarSTU; at international scientific and scientific-practical conferences "Integration of science, education and production – the basis for implementing the Nation's Plan", Karaganda, KarSTU (Saginov Readings No. 9, June 22–23, 2017), (Saginov Readings No. 10, June 14–15, 2018), (Saginov Readings No. 11, June 14–15, 2019); "Development of technical sciences in the modern world", Voronezh (December 11, 2017); MATEC Web of Conferences "Information and Measuring Equipment and Technologies", Tomsk, 2018; "Achieve the Best Scientific Achievements", Sofia (March 12–13, 2018); "Sixth International Conference on Advances in Computing, Communication and Information Technology – CCIT 2018", Switzerland, 2018.

Implementation of work in industry. Within the framework of economic contractual studies, technical solutions have been developed for

selecting a scheme and calculating the parameters of anchor fastening of mine workings for the operating conditions of the Kostenko and Shakhtinskaya mines of the Karaganda coal basin. Technical solutions are currently undergoing pilot testing at the mines of the ArcelorMittal Temirtau Management Company. The structural scheme for calculating the parameters of single-, double-level, and combined anchor fastening is included in the revised instructions for calculating and using anchor supports in the mines of the Karaganda coal basin.

Main scientific results. The results of the conducted research were published in 19 printed works, including 1 monograph, 2 articles and 2 conference reports indexed in the Scopus database, 3 articles published in publications recommended by the Committee for Control of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan. The novelty of the results is confirmed by one patent for an invention, two certificates of inclusion in the state register of rights to objects protected by copyright.

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