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**«Research of combined support structures
and ways of their improvement»**

6D070700 – Mining

ANNOTATION

to the dissertation work for the degree of
Doctor of Philosophy Ph.D.

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Relevance of the research problem. Currently, the construction of underground structures and mine is growing rapidly in our country. In the mining industry and transport systems, the role of horizontal and inclined mine workings is very large. They cross an array of rocks with different stability characteristics along their course. At present, only one type of support is used in mine workings to secure complex preparatory workings (gallery, crosscut, and adit), without taking into account frequent changes in mining and geological conditions in the massif, that crosses it along its length. In general, for fixing the workings account for 30-40% of the funds spent on sinking the workings, so the provided new, inexpensive, innovative design of the support is relevant. It is especially necessary to conduct scientific work to create a rational innovative technology for the passage of underground workings in an array with complex mining and geological conditions.

Due to the different stability and stress-strain characteristics of rocks in the passing mass of the workings, the load-bearing capacity of some sections of the support is favorable, that is, such sections of the workings can be fixed with light, cheap and technologically available supports.

Therefore, the determination of the boundaries of areas formed by unstable rocks with high fracturing, with altered stability of the massif, taking into account the influence of the zone of tectonic faults, is also a very urgent issue.

This new approach will make it possible to secure the workings, divide the workings into separate sections along the working route, suitable for specific geomechanical conditions, with fasteners of various structures. As a result, it is possible to achieve an improvement in the technical and economic indicators of tunneling and an increase in labor productivity. The presented argued method and methods of fastening can be widely used in the mining industry.

Object of research: Horizontal development workings in areas with difficult mining and geological conditions, tectonic faults, passing in a rock mass with different physical and mechanical properties.

Purpose of the work: To present a rational system of fastening and construction of combined supports based on a detailed study-analysis of the features of each of the individual sections of the rock mass and stress-deformation states that arise in mine workings, as permanent fasteners when driving a transport drift at the horizon + 230m (260) of the "Beskempir" mineral deposit. Study of their structural and bearing characteristics, analysis and substantiation of the technical and economic indicators of individual support elements.

Subject of research: Based on the determination by the modeling method of the zones and magnitudes of the distribution of the stress-strain state of the massif, in individual sections of the mine, especially in places with tectonic faults, with a breakdown into separate sections selected for a specific magnitude and direction of rock pressure, as well as geomechanical processes occurring in the massif parameters and structures of supports for the transport roadway were calculated. As a result of the research, it is possible to reduce the cost and labor intensity of underground works, adjust the resistance and control the bearing characteristics of the fastening.

Relevance of the research problem: At present, only one type of fastening is used to fasten complex development workings (gallery, crosscut) without taking into account the frequent change in the mining and geological conditions of the massif along its length.

For the object of research, a monolithic concrete lining is used as the main permanent fastening at the "Beskempir" and "Akbakay" mines. At the same time, unreasonable reserves of strength of the lining are often created in areas with favorable mining and geological conditions. All this leads to a deterioration in the indicators of tunneling works, an increase in the labor intensity of underground works and the estimated cost of driving underground workings.

Existing and used in difficult mining and geological conditions of the "Beskempir" mine, when the projected drifts intersect the zones of geological faults, traditional types and methods of securing and maintaining mining workings becomes expensive and labor-intensive.

To do this, it is necessary to simulate the stress-strain state of the "Beskempir" mine massif (+230m) and determine the stability of rocks by several alternative methods. According to the results of the research, it is very important to determine the boundaries of the sections along the gallery, consisting of unstable sections with high cracks, the stability of the stress properties of which have changed due to the influence of tectonic disturbances.

This innovative approach makes it possible to secure sections of workings, dividing them along longitudinal sections, with fixation by various structures suitable for specific tectonic conditions. As a result, it is possible to improve the technical and economic indicators of underground mining and increase labor productivity. The fastening methods offered by the research results of the dissertation work can be used in other mines.

To solve the tasks outlined in the dissertation, the following researches are conducted:

- a digital assessment of the stress-strain state and physical and mechanical properties of rocks was determined, based on the analysis of actual geological data, stratigraphic columns of the studied massif were compiled and the lithological features of the deposit were established;
- the area of distribution of the influence of tectonic faults in the established zones of weakening was determined using the method of numerical modeling;
- based on the modeling of specific values of stress-strain loads arising in the working area in the "Rocks-massif-working" system, it is determined with a breakdown by sections in accordance with the distribution zones;
- in the system "Rocks-massif-working", the actual values of the stress-strain loads at each section arising in the immediate vicinity of the zones of propagation from the working are determined by modeling;
- the stability of rocks at rest has been studied by three alternative methods in accordance with the specific mining and geological conditions of the development:
 - official traditional method (Building code II-94-80);

- by rating (RMR) by Z. Bieniawski and by drawing up a diagram by E. Hook (E. Noak);
 - N. Barton's empirical method (Q-rating);
- the types of rational fasteners and their designs are determined, suitable for fastening each section of the roadway, their parameters, in accordance with the stability of rocks;
 - the technical and economic parameters of the support structure were determined by comparison, analysis, the proposed specific support structure (CRS) for horizontal working, traditional and frame supports (monolithic concrete or frame) that could be installed in the given mining and geological conditions.

Scientific novelty of the work:

1. Using the method of numerical modeling, determine the zones of distribution of the influence of tectonic faults in the massif through which the transport gallery passes, having studied the strategy and lithological features of the field.
2. Based on modeling, the interaction and dimensions of the mine workings are determined, taking into account the state of the rock mass, the interaction of the system components in the system "Massive-technology-workings".
3. Determination of the stability of rocks in the mining area by three independent modern methods (Building code-II-94-80, RMR and Q-rating) and their analysis of determining the stability class of rocks with clear divisions of the boundaries of the driveway attachment areas.
4. Based on the research materials, a new innovative, safe and economical system of fastening technologies is proposed to ensure the stability of mine workings.
5. Based on the results of the experiments, recommendations were proposed to prevent rock collapse and eliminate unreasonable margin of strength of the support in areas with increased stability, and in areas with difficult mining and geological conditions to exclude destruction and strengthen the supports as a result of ensuring the bearing capacity of the base (primary) support using additional elements.

New scientific principles and results are defended in the dissertation:

- the choice of the optimal support structure in the underground workings was made as a result of detailed research and modeling, taking into account the stratigraphy, lithological features of the field, stress-strain states of the rocks of the massif, taking into account intersecting tectonic faults;
- the stability of rocks in the area of horizontal excavation is calculated by three independent methods. As a result of the analysis, a system of combined support structures with adjustable loads was proposed for securing a horizontal working;
- according to rock stability, the roadway was divided into sections, structures, technologies and fastening parameters were determined;
- as a result, an optimal fastening system has been proposed, if it is necessary to add a basic (main) fastening, additional structures increase the bearing capacity of the supports;

- it has been established that the use of a support structure of adjustable resistance in comparison with the use of traditional fasteners made of monolithic concrete or a frame allows 1.5-1.6 times to accelerate the rate of tunneling and 3.0-3.2 times to minimize the costs of fastening the gallery.

Validity and reliability of scientific principles, conclusions and recommendations:

- with extensive data from the analysis and analysis of actual geological data and test materials and sufficient laboratory experiments;

- satisfactory correspondence of indicators and analytical values obtained using the limiting elemental methodological and other programs for numerical simulation Examine-2D on a computer (the difference does not exceed 15-20%);

- the actual state of the structure and lithology of the rock mass in the area of intersection of the horizontal transport roadway is confirmed by accurate geological data;

- the indicators obtained in the course of the study using the finite elements of modern numerical modeling of the Examine-2D program and other programs correspond to traditional analytical solutions;

- dozens of core samples taken from wells at each geological section were tested in a special laboratory, the test results are characterized by a reliability of more than 0.9 and an error limit of no more than 10%.

Personal contribution of the author to obtaining the results of the dissertation:

- when studying structural changes and the main physical and mechanical properties of rocks in the "Beskempir" mine, a detailed study of the rock massif in difficult rock geological conditions, defining the boundaries of areas subject to tectonic changes;

- comparative determination of the stress-strain state in the working area crossing such lines by three methods (Building code, V. Benyavsky and Hook, Barton) using special modern computer programs to determine specific categories of rock stability in each section;

- based on the data obtained, it was determined that the drift can be secured by fastening structures with different bearing capacity and structure that can withstand geomechanical processes in the rock mass;

- a new method of fastening horizontal tunneling is proposed, in which methods of fastening (sprayed concrete) are substantiated in areas with a high stability of the workings, as well as in unstable areas with high load-bearing fasteners, i.e. load-controlled anchorage system;

- the technical and economic indicators of the proposed fastening system have been determined and compared with other alternatives.

Scientific value of the work:

Because of a special study of the stress-strain state of complex geological layers of the rock mass, in which the roadway passes, the stability of the surrounding rocks was determined using several new methods and, as a result, taking into account the influence of tectonic disturbances.

As a result of a special study of the stress-strain states in the rock mass intersected by the mine route, taking into account the influence of tectonic faults, it was found that the stability of rocks in the vicinity of the mine was determined using several new methods and, as a result, a system of combined supports with various structures, controlled and regulated by the values of the load-bearing capacity of the mine, is reasonably presented.

Practical value of the work:

It has been substantiated that in areas with difficult mining and geological conditions, such as the "Beskempir" field, using a combined support system with resistance control by controllable values of the bearing capacity, adjusted to the stability properties of the rock mass, it is possible to fasten the workings with effective fasteners, which make it possible to reduce costs of materials and labor for fastening, significantly increases productivity and ensures safe mining.

Information about patent research and its results:

The analysis of patent works on the issues of geomechanics and geotechnology of the experience of underground development of deposits with difficult mining and geological conditions was carried out. Publications on this topic were reviewed abroad and in the CIS countries. As a result of such studies, it was necessary to carry out special research work to provide the "Beskempir" field with a system of combined fastenings of various designs, with controlled bearing properties, when driving preparatory horizontal tunneling in a massif with difficult geological conditions and tectonic faults.

Information on metrological support of scientific research works. During the research work on the topic of the dissertation, GOST 7.32-2001 "Interstate Standard for accounting for research works", GOST 2.105-95 "Interstate Standard for a Unified System of Project Documentation", "Quality Management System", State standards of the Republic of Kazakhstan, current rules and requirements in the Republic of Kazakhstan, as well as methodological guidelines for metrological support were used.

Approbation of the work. The main scientific provisions and results of the dissertation were presented at the following international scientific and practical conferences:

1) "Automobile and transport equipment: problems and prospects of development", International Scientific and Practical Conference, KazADI named after L.B. Goncharov. - Almaty. 2019, - p. 56-61;

2) International scientific and practical conference "Satpayev Readings 2020". - Satbayev University. Almaty. 2020, - p. 380-383;

Publication of results. The main scientific results and recommendations of the dissertation were published in 24 publications, 1 article in the journal 60% of the included in the Scopus database (Q2/0.24), and 1 article in the quarterly journal Q3/0.13 included in the Scopus database, including 9 scientific publications recommended by the Committee for Control in the Sphere of Education and Science of the Ministry of Education of the Republic of Kazakhstan, 13 articles in the work of the International Scientific and Practical Conference.

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Structure and scope of the dissertation. The dissertation consists of an introduction, 4 sections, a conclusion, a list of used sources of 50 titles and 3 appendices. The work is presented on 120 pages and contains 45 figures and 24 tables.