

ABSTRACT

of the dissertation for the degree of Doctor of Philosophy (PhD)
in the educational program 8D07302 – «Production of building materials, products
and structures»

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on the topic:

«DEVELOPMENT OF MODIFIED CONCRETE COMPOSITIONS FOR STRENGTHENING QUARRY WALLS»

The aim of this work is to develop effective compositions of modified concrete to strengthen the walls of the quarry and underground excavations at the Akzhal deposit, considering the specific mining, geological, and geomechanical conditions, as well as the use of beneficiated waste as a part of the concrete mixture.

To accomplish this goal, the following **tasks** were solved

- analyzed the mining and geological characteristics of the Akzhal deposit, determining the stability of quarry walls.
- studied the chemical, physical, and mechanical properties of beneficiated waste, mine water, and process water for their potential use in concrete mixtures.
- developed formulations for modified concrete that are suitable for reinforcing quarry slopes and underground excavations.
- determined the physical and mechanical characteristics of modified concrete containing beneficiated waste and mine water.
- implemented the research findings in production and education.

Research methods.

The research methodology is based on a combination of theoretical and empirical approaches, including generalization, comparative analysis, experimentation, and the principles of systems thinking, mathematical modeling, and planning and processing of experimental data.

We used a systems-based approach in our research on construction materials, taking into account the interrelationships between material composition, structure, and properties. This allows us to optimize production and operational processes more effectively.

To conduct our experiments, we used laboratory samples and modern analytical techniques such as electron microscopy, chemical analysis, differential thermal analysis, infrared spectrometry, and X-ray diffraction. These methods provide more accurate and reliable results, allowing us to assess material properties and quality with a high level of confidence.

All tests were conducted in accordance with the state standards and other relevant regulatory documents of Kazakhstan. They were performed in accredited laboratories.

Scientific provisions submitted for defense:

1. The chemical and physical-mechanical properties of processing plant waste and mine and process water make it possible to determine their scope of application as components of a concrete mix.

2. A method of quarry slope strengthening has been developed, aimed at improving slope stability and providing a reliable solution for long-term quarry operation under complex mining and geological conditions.

3. An innovative composition of shotcrete concrete has been developed to strengthen disturbed rock masses in underground workings.

The scientific novelty of this work is that it:

- justification of the use of waste from the Akzhal deposit as components for modified concrete mixtures;

- determination of the physical and mechanical properties of modified concrete mixes, mixed with mining and process water, to improve their performance characteristics under various climatic conditions;

- establishment of patterns of influence of climate factors, including hot and dry climatic conditions, on hydration processes and concrete durability;

- development of an innovative shotcrete concrete mixture composition, which allows, on the one hand, strengthening disturbed rock masses in underground workings and, on the other hand, effectively using waste from the beneficiation plant;

- development of an innovative technique for strengthening a quarry slope, aimed at improving the reliability of quarry side strengthening and preventing rock shedding from the slope surface and possible collapse of quarry sides.

The practical significance of the research:

The results of the study have been implemented at the Akzhal lead-zinc deposit, Nova-Zinc LLC. They have also been integrated into the educational process by supplementing the discipline «Mine surveying in open-pit mining» for students of the educational program 6B07205 - «Mining Engineering». Additionally, they were used to enhance the discipline of «Geomechanical and mine survey monitoring» for master's students in the educational program 7M07227 – «Mine surveying».

A copyright certificate No. 1344, dated December 22, 2022, was obtained for the scientific work titled «Method for Strengthening Quarry Slopes». The patent of the Republic of Kazakhstan for invention No. 36246, dated June 2, 2023 «Method of consolidating the slope of a quarry», and a patent of the Republic of Kazakhstan for invention № 36220 dated May 5, 2023 «Composition of solution for strengthening disturbed rock mass in underground workings», which may serve as a future supplement to existing regulatory documents.

Main results:

- theoretically substantiates and experimentally confirms the possibility of using waste from the Akzhal deposit as components for modified concrete compositions. This allows for significant improvement in the mechanical properties of the material and increased environmental friendliness.

- determines and experimentally confirms physical and mechanical characteristics of modified concrete mixtures mixed with mine water and process water. This improves their performance properties in various climatic conditions.

- establishes patterns of influence of climatic factors, such as dry hot climate, on hydration processes and the durability of concrete. This enables optimization of compositions for intensive use in different conditions.

- developed an innovative shotcrete concrete mixture that allows, on the one hand, strengthening disturbed rock masses in underground workings and, on the other, effectively using waste from the processing plant.

- developed an innovative method for reinforcing the slope of a quarry to increase the reliability of slope reinforcement and prevent rock shedding from the slope surface and possible collapse of quarry walls.

The research for the dissertation was conducted in accordance with the Priority Direction of Development of Science of the Republic of Kazakhstan for 2024-2026 «Ecology, environment and rational use of natural resources».

The research for the dissertation was also conducted as part of the Project for grant financing for young scientists for 2020-2022 titled «AP08053410 - Development of innovative methods for forecasting and assessing the state of a rock massif to prevent man-made Emergencies» and the Program-targeted funding for scientific and technical projects for 2023-2025 titled «BR21882292 - Integrated development of a sustainable construction industry: Innovative technologies, Production optimization, Efficient use of resources, and Creation of a technology park» which was conducted by NPJSC «KazNRTU named after K.I. Satbayev».

The author's personal contribution includes active participation in the formulation of the research goal and the setting of tasks, as well as the preparation of scientific publications, abstracts for reports, and the filing of a patent application. The author has personally conducted laboratory studies and tests, or participated in them directly. In addition, she tested the developed technology under industrial production conditions. For joint publications, the author contributed significantly to the conduct of experimental studies, analysis of the data obtained, preparation and formatting of materials, submission of them, and further support.

Publications and approval of the work:

The main provisions of the dissertation work have been published in 5 printed works

1. «Preparing solutions based on industrial waste for fractured surface strengthening», News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences, 2020, Vol.5, pp.13-20. Scopus Q3, DOI: 10.32014/2020.2518-170X.11

2. «Effective strengthening solutions for fractured rock masses using tailings», Eurasian Mining, 2022, №1, pp.59-63. Scopus Q2, DOI: 10.17580/em.2022.12.

3. «Prospects of using the polymetallic ore processing waste for producing hardening mixtures», Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 2022, (3), pp. 88-94. Scopus Q3, <https://doi.org/10.33271/nvngu/2022-3/088>

4. « Filling mixtures based on limestone tailings », News of the National Academy of Sciences of the Republic of Kazakhstan, Series chemistry and technology. – Almaty, 2022, №1, p.11-19.

5. «Green» economy in building materials», Mining Journal of Kazakhstan, 2020, No. 7, pp.45-48

The scientific, experimental, and practical results of our work were presented and discussed at 4 international and domestic scientific conferences.

1. «Sustainability of mountain Structures», Scientific discussion (Praha, Czech Republic), VOL 1, No 41, (2020), pp. 35-38

2. «Processing of enrichment waste for the purpose of obtaining building materials», Problems and prospects of integrated development and conservation of the earth's interior: 4th International scientific school of academician K.N. Trubetskoy. - Moscow: Institute for Problems of Integrated Development of Subsoil Resources of the Russian Academy of Sciences, 2022. - pp. 35-38.

3. «The influence of ultrasonic activation of enrichment tailings on the strength properties of the hardening mixture», Proceedings of the Int. scientific-practical. conf., dedicated to the 115th anniversary of the Corresponding Member of the Academy of Sciences of the Kazakh SSR A.Zh. Mashanov and the 100th anniversary of the Academician of the Academy of Sciences of the Kazakh SSR Zh.S. Erzhanov «Innovative technologies in geospatial digital engineering». - Almaty, 2022. - pp.29-35. ISBN 978-601-323-277-5.

4. «Use of enrichment waste to obtain building materials», Proceedings of the International Surveying Forum «Geospatial Digital Engineering in Geodesy, Mine Surveying and Geomechanics». - Karaganda: KarTU named after Abylkas Saginov, 2023. - pp.42-47. ISBN 978-601-08-2196-5.