ABSTRACT

of the dissertation for the degree of Doctor of Philosophy (PhD) in the educational program 8D07305 – "Construction and production of building materials and structures" of **Berdikul Nazerke Imanalikyzy**

on the topic **"Improving the performance properties of fine-grained concrete using effective chemical additives".**

The relevance of the dissertation research

In the Republic of Kazakhstan, the development of urban transport infrastructure is currently a significant issue. As a result, highways are being built, metro and urban railway lines are being laid, and channels for engineering systems, including tunnels and other underground structures, which require the use of fine-grained concrete mixtures, are being constructed. However, the high pace of industrial development requires a large amount of electricity, which leads to the formation of substantial amounts of fuel ash and slag waste, including fly ash (FA), which negatively affects the environmental situation in the country and requires disposal.

For the rational disposal of FA, it can be used in the composition of mineral binders, as well as fine active mineral additives in concrete and construction mortars. This would allow for the replacement of expensive imported microsilica and highly active metakaolin and bind free calcium hydroxide (CH) into less soluble and more reactive low-basic calcium hydrosilicates (CSH).

Thus, the use of local FA to produce efficient fine-grained concrete (FGC) is a promising solution. To obtain high-strength and corrosion-resistant FGC, local zeolite can be used as a mineral additive in the concrete mixture, as well as low-calcium fuel FA as part of the binder. Additionally, a chemical additive based on polycarboxylate ethers will allow for the creation of a denser and more reinforced structure of cement stone.

Objective and tasks of the research

The main objective of the dissertation is to improve the performance properties of FGC by modifying its structure using a complex additive.

To achieve this goal, the following tasks need to be accomplished:

- To justify the composition for producing a complex additive to improve the technological properties of fine-grained concrete mixtures and the performance properties of FGC;
- To establish the relationships between the properties of fine-grained concrete mixtures and FGC with a complex additive;
- To justify new technical solutions aimed at increasing the durability of FGC by using fly ash and zeolite to densify the structure of the concrete;

- To determine the optimal composition and properties of binders using mechanically activated FA from CHP-2 to optimize the concrete formation process;

- To justify the possibility of increasing the strength of fine-grained concrete by introducing chemical additives into its composition;

- To develop an optimal composition of fine-grained concrete with high performance properties based on local raw materials such as zeolite and chemical additives;

- To assess the influence of FA and zeolite on the strength of fine-grained concrete and determine the dependence of the concrete mixture's strength on the consumption of chemical and mineral additives.

Object of the research

The object of the research is fine-grained concrete with technogenic, chemical, and active additives. The technology for obtaining and applying effective fine-grained concrete using efficient chemical additives.

Subject of the research

The subject of the research is effective high-strength fine-grained concrete with a denser structure and improved mechanical properties. The main focus is on optimizing the composition of this concrete to enhance its performance characteristics, such as strength and frost resistance. The goal is to use local waste and minerals as components of the mixture.

The scientific novelty of the research

- The possibility of producing fine-grained concretes with improved performance properties due to the use of chemical additives, allowing for a reduction in the water-cement ratio while maintaining the required workability, has been substantiated.

- It has been established that the use of the developed complex additive improves the rheological properties of the concrete mixture, leading to an increase in the main physical, technical, and performance characteristics of the concrete (strength, water resistance, frost resistance).

- New technical solutions aimed at reducing the amount of cement in FGC and increasing the strength and durability of FGC by using fly ash and zeolite to densify the concrete structure have been substantiated.

- The mechanical activation of fly ash, which accelerates cement hydration and activates the formation of CSH (calcium hydrosilicate), has been shown to improve the mechanical properties of cement stone, making the concrete stronger and more resistant to various impacts.

- A composition of fine-grained concrete using mechanically activated fly ash has been developed, characterized by improved strength and frost resistance, while simultaneously reducing cement consumption in the concrete.

Methodology and research methods

The methodological basis of the research includes theoretical and empirical methods based on generalization, comparison, experiment, systematic approach, mathematical modeling, planning, and processing of experimental results.

The work was carried out using a system-structural approach in building materials science, which allows for consideration of the relationships between the composition, structure, and properties of the material, ensuring the optimization of its production and operation processes. Experimental research on laboratory samples using modern analytical methods, such as electron microscopy, X-ray phase analysis, photocolorimetry, laser granulometry, and chemical analysis, made it possible to obtain more accurate and reliable results and assess the quality and properties of the material obtained. This approach ensures high reliability and accuracy of the data, which is crucial when developing new building materials and optimizing their properties.

List of publications:

1. Fine-grained Concrete Utilizing Mineral and Chemical Additives // News of the National Academy of Sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences. – 2022. – №4. – P. 44-54 (Scopus Q3, Percentile 43%).

2. The Effect of Mechanical Activation of Fly Ash on Cement-Based Materials Hydration and Hardened State Properties // Materials. – 2023. – №16(8). – P. 2959 (Scopus Q2, Percentile 62%).

3. Increasing the resistance of concrete to sulfate corrosion // Bulletin of the National Academy of the Republic of Kazakhstan. Series of Chemical Sciences. – 2022. – №2(451). – P. 63-73.

4. Investigation of the strength of fine-grained concrete with a plasticizing additive // Construction and Transport. – 2024. – №3. – P. 231-238.

5. Education and development of spatial structures of concrete // Science and innovative technologies. – 2022. – №2(23). – P. 3-10.

6. Application of fly ash as a cementing material // Materials of the 7th international conference "Youth and Science: New Trends of Independence" (Astana, 2023. – P. 34-37).

7. Research of the optimal concentration of superplasticizer in fine-grained concrete // Materials of the conference "II International Book Edition of CIS Countries" (Astana, 2023. – P. 22-26).

8. Patent 36297. Mixture for the preparation of fine-grained concrete.

9. Patent 36201. Thermal insulation material based on rice husk.

Structure and volume of the dissertation

The dissertation consists of an introduction, four chapters, a conclusion, and a list of references with 106 sources. The work comprises 125 pages of typed text, including 35 tables, 54 graphs, and 13 figures.