ABSTRACT

of the dissertation work
on the topic: “Development of Energy-Saving Technologies for the Production of Lightweight Concretes Based on Industrial Waste”
submitted for the degree of Doctor of Philosophy (PhD)
under the educational program 6D073000
“Production of Building Materials, Products and Structures”

The priority areas of development in the science field of the Republic of Kazakhstan for 2024–2026 are identified as: “Ecology, Environment and Rational Use of Natural Resources” and “Energy, Advanced Materials and Production.”

The objective of the dissertation is to development of the composition of the binder and technological parameters for producing structural and heat-insulating cellular concrete of non-autoclaved hardening based on a modified system of cement-free mixed binder from cullet and liquid glass, study of its properties, and selection of rational areas of application.

To achieve this objective, the following tasks were set:

- Develop a theoretical basis for the possibility of obtaining non-autoclaved concrete based on glass cullet;
- Develop a binder composition;
- Select effective structure-forming additives;
- Establish patterns linking compositions and technological parameters with the structures, physical-mechanical, and operational properties of the materials obtained;
- determine the most rational compositions of cellular concrete in accordance with the area of application of the finished product;
- study the main physical and mechanical properties and evaluate the operational durability of cellular concrete based on glass binder.

Research methods:

Literature review of domestic and foreign sources, including the study of patents for inventions and utility models, copyright certificates, and global experience aimed at researching the use of industrial waste in the production of building materials; conducting standard testing methods for non-autoclaved aerated concrete; conducting electron microscopic studies, conducting tests in accredited laboratories; pilot industrial testing of non-autoclaved aerated concrete based on cullet.

The scientific novelty consists of:

- Theoretical foundations have been developed for producing structural and thermal insulation concrete with a cellular structure and non-autoclaved hardening based on a cement-free mixed binder made from cullet and liquid glass.
- Compositions of cement-free mixed binder made of cullet and liquid glass capable of hardening at temperatures up to 90°C using qualitatively new structure-forming additives have been developed.

- Patterns linking compositions and technological parameters with the structures, physical, mechanical, and operational properties of the obtained materials have been established.

- The optimal compositions of non-autoclaved cellular concrete based on cement-free mixed binder made of cullet and liquid glass have been determined, ensuring the production of structural and thermal insulation material with maximum physical and mechanical properties.

- The main strength, deformation, and thermophysical properties of non-autoclaved cellular concrete based on a cement-free mixed binder made from cullet and liquid glass were studied.

Scientific statements submitted for dissertation defense:

- Composition of highly porous polystyrene concrete as a thermal insulation layer for three-layer wall panels;

- Effect of a complex additive on the physical and mechanical properties of highly porous polystyrene concrete;

- Technological solution for producing three-layer wall panels, which reduces the cost of products through the use of an optimal composition of the thermal insulation layer and automation of operations.

Practical significance:

- Expanded raw material base for the production of effective structural and thermal insulation building materials with a cellular structure made of non-autoclaved concrete based on a cement-free mixed binder made of glass cullet and liquid glass with modifying additives from production waste;

- Formulations and technology have been developed for the production of cement-free binder and non-autoclaved cellular concrete with maximum use of secondary resources and waste.

- A method has been developed for selecting compositions of modified cement-free mixed binder from cullet and liquid glass for the production of non-autoclaved cellular concrete for structural and thermal insulation purposes.

- Non-autoclaved hardening cellular concrete based on glass cullet of density grades D600-D800, strength classes B1.5-B2.5, and reduced thermal conductivity of 0.12-0.16 W/m-°C, respectively, has been obtained.

- Technical specifications and technological regulations have been developed for the manufacture of small wall blocks from non-autoclaved cellular concrete based on a modified cement-free mixed binder made from glass cullet and liquid glass.

Personal contribution of the candidate is in developing the objectives and tasks, selecting the research methods, as well as establishing the scientific and technological principles for producing highly porous polystyrene concrete from industrial waste. All laboratory studies and tests were carried out personally by the author or with his direct participation. The developed technology was tested under industrial production conditions. In co-authored published articles all the experimental research results, analysis, preparation, formatting, submission, and follow-up of the materials belong to the author.

Reliability of the research results

Laboratory tests were conducted at the following accredited laboratories: the engineering testing laboratory "Comprehensive Development of Mineral Resources" at the Abylkas Saginov Karaganda Technical University, and the testing center of KaragandaTechnoService LLP, both equipped with modern equipment. The results of the laboratory studies are substantiated in accordance with the conclusions and recommendations and confirmed by pilot industrial tests.

Work Testing. The main results of the dissertation have been published in the following journals/conferences:

- "Main Preconditions for Energy Conservation Building Products from Gas-Steel and Foam Glass Concrete." Bulletin of the University of Karaganda – Physics, 2018, No. 4 (92), pp. 93–100. Web of Science (Q4).
- "Quality Improvement of Construction Products Based on Technogenic Cullet." Glass and Ceramics (English Translation of Steklo i Keramika), 2019, Vol. 76, No. 7–8, pp. 274–277. DOI: 10.1007/S10717-019-00182-7.
- "Energetics Metrics for Foam-Glass Concrete Building Products." Glass and Ceramics (English Translation of Steklo i Keramika), 2020, Vol. 77, No. 7–8, pp. 267–271. DOI: 10.1007/S10717-020-00285-6.
- "Investigation of the Technology for Producing Binders Based on Glass Waste." Proceedings of the University, No. 2 (95), Karaganda, 2024, pp. 224–230. ISSN 1609-1825 (Print), ISSN 2710-3382 (Online).
- "Prospects for the Use of Glass Waste in Construction Materials." International Scientific and Practical Conference "Integration of Science, Education and Production – The Basis for Implementation of the National Plan" (11th Saginov Readings), Karaganda, 2019, pp. 243–244.
- "Granulometric Factor in the Formation of Properties of Composites Containing Glass Waste." International Scientific and Practical Conference "Integration of Education, Science and Production" (17th Saginov Readings), Karaganda, 2025, pp. 364–366.
- Patent of the Republic of Kazakhstan for a utility model "Complex of Gas-Glass Concrete Products Based on Technogenic Glass Waste," No. 5312, 2020.
- Patent of the Republic of Kazakhstan for a utility model "Complex of Gas-Glass Concrete Products Based on Technogenic Glass Waste," No. 5376, 2020.
- Certificate of Entry into the State Register of Rights to Objects Protected by Copyright, No. 2877, 2019.
- Certificate of Entry into the State Register of Rights to Objects Protected by Copyright, No. 63502, 2025.
- Certificate of Entry into the State Register of Rights to Objects Protected by Copyright, No. 63599, 2025.