ANNOTATION

dissertaton work on the topic "Development of a technology for modified concrete based on technogenic waste from the construction industry and non-ferrous metallurgy in southern Kazakhstan", submitted for the degree of Doctor of Philosophy (PhD) in the Educational program 8D07340 - "Production of building materials, products and structures"

NURYMBETOVA RAUSHAN UALIKHANOVNA

The objective of the study was to develop technologies for the production of concrete using industrial waste for the manufacture of construction products while simultaneously reducing the negative impact on the environment and ensuring the protection of the population from the harmful effects of technogenic waste.

To achieve the aim of the dissertation, the following tasks were defined:

- To analyze the current state of the use of man-made waste in the construction industry;
- To substantiate the possibility of their use as fillers in heavy concrete through a comprehensive analysis of waste from the construction and non-ferrous metallurgical industries of Southern Kazakhstan;
- Development of a mathematical model of the dependence of the physical and mechanical properties of concrete on the proportion of man-made aggregates;
- Study of the influence of fillers based on man-made waste on the physical and mechanical properties of heavy concrete and the selection of the optimal composition of heavy concrete based on man-made waste;
- Justification of technical and economic efficiency of using man- made waste in heavy concrete production technology.

Research object: Heavy concrete, modified technogenic waste from the metallurgical and construction industries of Southern Kazakhstan.

Subject of the study: To study the influence of industrial waste on the rheological properties of concrete mixtures, cement hydration processes, and the formation of the phase composition and microstructure of cement stone, as well as the physical, mechanical, and operational properties of heavy concrete.

Working hypothesis: The combined use of traditional and technogenic fillers, binder, and modifying admixtures in optimal proportions makes it possible to purposefully control the hydration and structure-formation processes, reduce the consumption of cement and natural raw materials, and produce high-durability concrete by forming a dense cement stone structure.

Research methods. Physico-chemical studies of the raw materials and the resulting concrete were conducted in the laboratory of the Testing regional laboratory of engineering profile «Structural and biochemical materials» of the South Kazakhstan University named after M. Auezov. X-ray diffraction analysis was performed on a D&ENDEAVOR instrument from Bruker (Germany). The diffraction patterns were interpreted using data from the JCDD file: a database of powder diffraction data (PDF2) and diffraction patterns of pure minerals. The chemical composition

of the waste was determined by scanning electron microscopy using a JEOL-6490 LV scanning electron microscope (SEM). The results of differential thermal analysis were determined on a L.ErDey Q 1500 D (Demo) derivatograph in air in the temperature range from 20 to 1000 °C in the dynamic heating mode (reference material – calcined AL_2O_3) (DT/DT = 10) and a sample weight of 500 mg with a division value of the sample weight change scale of 500 μV. Physico-mechanical tests of the samples were carried out based on standard methods in the laboratory «Testing of building materials, products and structures» of the South Kazakhstan University named after M. Auezov.

The main provisions submitted for defense (proven scientific hypotheses and other conclusions considered as new knowledge):

- Results of theoretical and experimental studies on the possibility of using industrial waste from Southern Kazakhstan in heavy concrete with specified performance characteristics;
- A mathematical model characterizing the dependence of the physical and mechanical properties of heavy concrete on the type and amount of fillers based on environment and ensuring the protection of the population from the harmful effects of technogenic waste;
- The results of the study made it possible to establish the influence of partial replacement of traditional fillers with man-made waste on the physical and mechanical properties of concrete;
- Results of physical and chemical studies of the influence of mineralogical composition and specific surface area of man-made waste on the strength of the contact zone of filler and cement stone;
- Results of physical-mechanical and physical-chemical studies of the dependence of chemical resistance of heavy concrete on the mineralogical composition of technogenic fillers;
- Results of physical-mechanical and physical-chemical studies aimed at optimizing the composition of heavy concrete based on man-made aggregates;
- Technical and economic feasibility of using fillers based on man-made waste in the production technology of heavy concrete.

Relevance of the topic. The accumulation of industrial waste is one of the most pressing problems in the modern world. This problem is of particular concern, especially given that Kazakhstan's industrial complex is primarily focused on resource extraction and processing, which leads to the generation of large quantities of waste. Clearly, a set of measures to eliminate common industrial waste and research in this area will expand its scale and improve the efficient use of shared resources by reducing costs for exploration, extraction, and processing of mineral raw materials.

Studies have shown that over 200 million tons of industrial waste have accumulated in southern Kazakhstan alone. Utilizing this waste in the construction industry, in turn, offers the construction materials market an excellent opportunity

to increase production using waste from local enterprises, meet basic needs, reduce production costs and dependence on imports, utilize large landfills, and improve the environmental situation in the region.

The most efficient way to utilize industrial waste is to use it as building materials, as only the construction industry can utilize it in quantities commensurate with the volume of waste generated. Industrial mineral deposits contain significant reserves of valuable raw materials, but the lack of effective technologies for their processing and utilization has necessitated the need for relevant research. Research in this area allows for resource conservation by expanding the scope of application and reducing the costs of exploration, extraction, and processing of mineral raw materials.

Justification necessity conducting scientifically research work. This dissertation combines modern theoretical concepts of concreting and the potential for integrated processing of regional industrial waste, ensuring the achievement of high scientific and applied, resource-saving, and environmentally safe results.

Description of the main results of the study.

- For the first time, the possibility of using industrial waste from Southern Kazakhstan in heavy concrete with specified performance characteristics was demonstrated theoretically and experimentally, its effectiveness was determined, which laid the necessary foundation for its practical application;
- The dependence of the physico-mechanical and operational properties of concrete on the type and mineralogical composition of aggregates based on technogenic waste was studied, and it was established that the increase in concrete strength depends on the specific surface area and mineralogical composition of the aggregates. Physico-chemical studies showed that technogenic waste contains the minerals calcium carbonate, quartzite, and dolomite. It was also found that the cement paste interacts with carbonate aggregates, forming calcium carbonate of various compositions in the $CaCO_3$–$Ca(OH)_2$–H_2O system, which increases the mechanical strength of the contact zone between the cement stone and the carbonate rock and thus has a favorable effect on concrete strength. In turn, silicon dioxide reacts with calcium hydroxide ($Ca(OH)_2$ + SiO_2 + mH_2O = $CaO{\cdot}SiO_2{\cdot}nH_2O$), forming low-basic calcium hydrosilicates, which create tight contact adhesion with the cement stone.
- The dependence of the chemical resistance of heavy concrete on the mineralogical composition of technogenic aggregates was determined. It was found that the higher the aluminum oxide content of the aggregates, the lower their resistance to sulfate corrosion. The sulfate corrosion resistance of concrete based on the aggregates used increases in the direction “almond aggregate” → “lead slag” → “Achots” → “Anskhv”.
- An optimal composition of heavy concrete based on technogenic aggregates, ensuring high strength and chemical resistance, was developed; replacing 50% of the traditional aggregates with aggregates based on Ansai (Anskhv) waste was shown to be highly effective. Experimental studies aimed at optimizing the composition of concrete based on Ansai technogenic aggregates using polycarboxylate superplasticizers showed that using the JP-700HQ superplasticizer at a dosage of 0.8% reduces the water-cement ratio (W/C) from 0,42 to 0,39 while obtaining a concrete mixture of equal workability.

This makes it possible to produce dense-structure concrete of class B40 with high chemical resistance (Kr = 0,83). It was established that the presence of up to 11% of highly dispersed barite dust in the Ansai (Anskhv) waste shifts the direction of the hydration reaction of these minerals toward the intensive release of new formations and binds them into insoluble compounds. When these products react with $Ca(OH)_2$, they form low-basic hydrosilicates, which helps optimize the physico-mechanical properties of the concrete.

- A resource-saving technology for heavy concrete based on aggregates from technogenic waste was developed. The use of technogenic aggregates was shown to yield an economic benefit of 2,834.4 tenge per 1 m³ of concrete when 50% of the traditional aggregates are replaced with Ansai technogenic aggregates, and 2,190 tenge when the modified optimal composition is used. The modified composition provides higher technical and operational efficiency owing to the improved physico-mechanical properties of the concrete.

Practical significance of the study:

- The proposed concrete compositions based on environment and ensuring the protection of the population from the harmful effects of technogenic aggregates can be widely used in civil, industrial and road construction, as well as in civil defense facilities, uranium mines and in the construction of nuclear power plants;
- The proposed technology for the production of concrete based on environment and ensuring the protection of the population from the harmful effects of technogenic waste allows for the development of resource- and energy-saving technologies in the production of heavy concrete and will reduce production costs, since, compared to traditional technology, it does not require additional equipment;
- The application of the proposed solutions will allow for the saving of mineral raw materials and the improvement of the environmental situation in the region due to the recycling of industrial waste;
- The use of aggregates based on environment and ensuring the protection of the population from the harmful effects of technogenic waste in heavy concrete technology provides economic efficiency of 2834.4 tenge when replacing 50% of traditional aggregates with man-made aggregates per 1 m³ of concrete and 2190 tenge when using a modified optimal composition.

Reliability and validity of scientific principles, conclusions and recommendations:

The reliability of the results, scientific findings and conclusions obtained in the dissertation work is confirmed by the fact that the experimental data do not contradict the theoretical rules, the reliability of the results of physical and chemical studies, as well as the correspondence of the results of laboratory tests to the data of industrial tests.

Compliance with scientific development directions or State programs.

The dissertation work was completed in accordance with the state-budget research plan of the South Kazakhstan University named after M. Auezov SFR and DP-21-02-06 on the topic «Improving the operational efficiency of

building materials, products and structures based on raw materials of the Turkestan region.»

The author's personal contribution. The author reviewed the literature on the topic of the dissertation, performed a comprehensive analysis of industrial waste in Southern Kazakhstan, and studied the impact of industrial waste on the physical and mechanical properties of heavy concrete. She proposed an optimal concrete composition and determined the technical and economic efficiency of using industrial waste in heavy concrete technology.

Testing the work.

Nine articles have been published on the topic of the dissertation, including 1 article in a scientific journal indexed in the international Scopus database (included in the Q_2 category), 3 articles in scientific journals recommended by the CQASHE MSHE RK, 5 articles were published in peer-reviewed scientific journals, as well as in the proceedings of international scientific-practical conferences and scientific-practical publications. A patent for a utility model of the Republic of Kazakhstan was received on the topic of «Concrete Mixture».

Publications:

- Study on the Possibilities of Utilizing Wastes of Polymetallic Combines in South Kazakhstan for the Production of Composite Heavy Concrete (article) Journal of Composites Science, 9, 468 September 2025. https://doi.org/10.3390/jcs9090468 (Q2)

- Concretes based on technogenic wastes formed during the mechanical processing of carbonate rocks (article) Technobius, 4(3) №0061, Astana, 2024. https://doi.org/10.54355/tbus/4.3.2024.0061

- Possibilities of using lead production waste in the production of building materials (article) Mechanics and Technology, No. 3 (85) Taraz 2024. – P.229-239. https://doi.org/10.55956/ZSJC3549.

- Mathematical modeling of the influence of aggregates based on mining waste on the physical and mechanical properties of heavy concrete (article) Mechanics and Technology, No. 2 (92) Taraz 2026. – P. 358-376. https://doi.org/10.55956/ZLLS1468

- Use of metal production waste in the production of lightweight concrete (article) «Auezov Readings-22: Academician Kanysh Satpayev - the Founder of Kazakhstan Science» Proceedings of the International Scientific and Technological Research Council dedicated to the 125th anniversary of Academician Kanysh Satpayev. Volume 7. Shymkent, 2024. -P. 134- 138.

- The possibility of using metallurgical waste as a mineral additive in concrete technology (article) «Auezov Readings-22: Proceedings of the International Scientific and Technological Research Council dedicated to the 125th anniversary of Academic- ian Kanysh Satpayev - the founder of Kazakh science». Volume 7. Shymkent, 2024. -P. 130- 134.

- Concrete on technogenic waste from southern Kazakhstan (article) Eurasian Education, Science and Innovation Journal Proceedings of the XIV

International scientific practical conference «Digital technologies in science and education» Volume 13, 30-31 January 2023. - P.35-38

- Composite materials with mineral additives based on metallurgical waste (article) International scientific conference «Progress and Science» Brussel, Belgium. 22-23.2.24. February 2024, No. 5, p. 40

- The effectiveness of using slag porous fillers in the production of lightweight concrete Proceedings of the 5th International Scientific Conference «Reviews of Modern Science» (February 1-2, 2024). Zürich, Switzerland. - P. 81-85

- Concrete mixture. Utility model of the Republic of Kazakhstan. No. 12448, 19.06.2026.

Structure and scope of the dissertation. The dissertation consists of an introduction, 5 chapters, a conclusion, a list of 150 references, and 4 appendices. The dissertation is 138 pages long, containing 56 tables and 51 figures.