ANNOTATION
of the thesis for the degree of
Doctor of Philosophy (PhD) in specialty 6D073000 – Production of Building Materials, Products and Strucutures
Mominova Saule

DEVELOPMENT OF TECHNOLOGY GAS SILICATE CONCRETE PRODUCTION ON THE BASIS OF PHOSPHORIC ASHES AND POLYMICT SANDS COMBINING WITH NATURAL WOLLASTONITE

Relevance of the research. The first president - Elbasy of the Republic of Kazakhstan N.A.Nazarbayev in his message to the people of Kazakhstan repeatedly noted that house construction should be considered as a kind of “engine” of the country's economic development. The large-scale construction of new housing will create and ensure the conditions for the accelerated development of the building materials industry, which will be in demand in erection of new and reconstruction of existing construction facilities. The main direction of city planning policies was energy saving with simultaneous improvement of the quality and durability of products. To date, this policy in the field gives its results.

In the Republic of Kazakhstan, energy saving issues and energy efficiency improvement are supported by law. In addition, the project of the Government of the Republic of Kazakhstan is being implemented under the State Housing and Communal Development Program “Nurla Zher” for 2020-2025. The construction of modern building industries with the use of natural raw materials, as well as off quality local raw materials and by-products of various industries for the development of new technologies, is a relevant, economically and environmentally favorable direction for the development of the building materials industry and the implementation of adopted laws and projects.

One of the most important tasks of modern housing is the reduction of energy-price for the production of building materials while improving the quality of products.

Experience in the construction of buildings using products and structures from cellular concrete indicates their high economic efficiency. It is possible to obtain three or four cubic meters of wall material in the form of gas concrete blocks from one cubic meter of mineral raw materials due to air involvement. A cellular concrete is lightweight and warm building material, so that it can and should help in the successful implementation of the country's housing problem. The development of the production of cellular concrete in Kazakhstan is also justified by the presence, in almost every area of raw materials for its production and the need to dispose of huge deposits of industrial waste and substandard raw materials.

In the global construction industry there was also a sharp increase in the production of products and structures from cellular concrete (gas-silicate concrete and foam concrete), mainly autoclave hardening.

Factories for the production of products and structures from cellular concrete are cost effective and energy-saving production in world construction practice.

Autoclave gas silicate concrete belongs to highly efficient materials so that the search for the production of such kind of materials relevant to enhanced standards to the heat resistance of wall and enclosing products and structures increased by more than three times. Despite the fact that non-autoclave production possess a number of advantages in comparison with autoclave one (there is no need for autoclaves and boilers). However, autoclave synthesis allows to produce high-quality cement-free gas silicate concrete, using industrial waste and substandard raw materials, which remain inert under normal hardening conditions (steaming, natural hardening) and thereby allow to reduce the severity of the problem of modern construction related to deficiency and high-cost of cement.

Fencing products from gas silicate concrete are more economical than products made of lightweight expanded clay aggregate and bricks due to its less density and energy intensity in production and operation, total capital intensity and complexity.

The problem of carrying out the construction of modern structures and buildings imposes growing demands on the existing building materials. At present, the requirements for the thermal protection of buildings and structures have been changed, respectively, the need for high quality, cheap heat-insulating materials and products has sharply increased. It is noted that a wide range of effective materials and identified technological methods, created by scientists and specialists, has made it possible in recent years, using experimental, pilot-scale installations and stands, as well as in industrial production, to work out fundamentally new effective technological schemes for obtaining new types of concretes with a wide range of performance characteristics due to varying within a wide range of the type of raw materials (binders and aggregates), varieties, optimization of the composition of multicomponent concrete and targeted technology management. The use and improvement of a new types of concretes, the use of industrial waste, which already includes the costs of labor, fuel, energy, the use of substandard raw materials - in many cases, are an effective way to ensure the production of cheaper materials with desired properties. Gas silicate concrete, used for the manufacture of enclosing structures, wall materials, due to its porous structure and, as a consequence, lower thermal conductivity, is most in demand on modern construction sites.

Polymict sand is promising for the production of gas silicate concrete, since the deposits of dune sands are unlimited, their use in the production of wall products is an urgent task and is of great practical importance. And the use of secondary raw materials for the production of gas silicate concretes is associated with the use of all the technical possibilities of processing waste from the phosphorus industry, the study of its chemical, mineralogical and grain size compositions.

As a result of replacing traditional raw materials with industrial waste, capital and operating costs are reduced, labor resources, fuel and electricity are saved. Involvement of waste in production, their utilization contributes to the reduction of huge areas occupied by storage facilities, dumps, and improves the state of the biosphere.

Therefore, the task of the construction industry in Kazakhstan in a market economy is to obtain products and structures from gas silicate concrete based on substandard local raw materials and by-products of chemical industries in

combination with natural wollastonite, which will reduce the weight of the building and improve the technical properties of products and structures.

In this regard, a global problem is posed to expand the raw material base of building materials, through the use of industrial by-products, local natural wollastonite raw materials and substandard local raw materials in the building materials industry. The improvement of the technology of building materials based on them will be carried out continuously, and go along the line of improving quality, reducing resource, labor and energy intensity. One of the main problems in the development of modern industry is the use of by-products of various industries, which stimulates the economic profitability of the production of one product. It is known that autoclaved gas silicate concretes, like ordinary cellular concretes, do not work well in tension in bending, are characterized by the formation of shrinkage cracks during hardening. Strength characteristics, as well as other properties of gas silicate concretes, can be increased by introducing the optimal amount of active mineral compositions, reinforcing fibers and its uniform distribution in the mixture. Domestic and foreign experience shows that dispersed reinforcement of gas silicate concrete with various fibers is the most promising, and is increasingly being used in many areas of construction. The advantage of dispersed reinforcement is that natural wollastonite fibers have increased strength of the concrete. Thus, to expand the range of effective materials, the development of a technology for autoclaved gas silicate concrete using natural wollastonite as a dispersed reinforcing microfiber is one of the most important scientific and practical problems.

The proposed thesis is devoted to the development of a resource-saving technology for the production of autoclaved gas silicate concrete based on by-products of chemical industries and substandard local raw materials in combination with dispersed reinforcing microfibers of natural wollastonite, which will solve the issues of resource conservation and environmental protection in industrial zones, and will lead to an improvement in physical, mechanical and operational characteristics of autoclave gas silicate concrete, and determines the relevance of the selected topic.

The thesis was carried out in accordance with the Law No. 541-IV dated January 13, 2012 “On Energy Saving and Efficiency Improvement”, the State Program of Housing and Communal Development “Nurly Zher” for 2020-2025.

The dissertation topic was carried out in accordance with the Law "On Energy Saving and Efficiency Improvement" dated January 13, 2012 No. 541-IV, the State Program of Housing and Communal Development “Nurly Zher” for 2020-2025.

The aim of the work is to develop the technology for the production of autoclaved gas silicate concrete and improve its properties by using phosphoric slag, polymict sand in combination with dispersed reinforcing microfiber of natural wollastonite.

In accordance with this aim, the following **research objectives** were identified:

– theoretically prove and experimentally determine the possibility of obtaining high-quality gas silicate concretes that meet the requirements of GOST 31360-2007;

– establish the regular influence of fine ground wollastonite on the flow characteristics of the gas silicate concrete mixture, it’s strength and physical and

mechanical properties;

– determine the optimal composition of gas silicate concrete based on phosphoric slag and polymict dune sand in combination with dispersed reinforcing microfiber of natural wollastonite;

– expand the raw material base for the production of gas silicate concrete using local natural resources, by utilization of industrial waste and substandard raw materials, solving environmental problems;

– develop process conditions for the production of gas silicate concretes with a density of 600-700 kg/m^3 on modern technology using waste from the phosphorus industry and dune sand together with fine ground natural wollastonite;

– produce an experimental-industrial batch of gas silicate concretes to verify the obtained data.

Object and subject of research:

The object of the study was gas silicate concretes based on phosphoric slags and polymict dune sands in combination with natural wollastonite.

Methods for achieving the goals: a literature review of domestic and foreign sources, including the study of patents for inventions and utility models, copyright certificates, world experience aimed at researching the use of industrial waste and substandard raw materials in the production of building materials; carrying out standard test methods for autoclaved gas silicate concrete, converting methods of differential thermal analysis (DTA) and methods of X-ray diffraction analysis, electron microscopic analysis, testing in accredited laboratories, conducting radiological, pilot-industrial tests of autoclaved gas silicate concrete.

The main scientific provisions for the defense:

– optimal compositions of gas silicate concrete;

– diagram of the mode of the optimal strength development of the plastic strength of a gas silicate mixture based on phosphoric slag and dune sands with fine ground natural wollastonite;

– established optimal process conditions of autoclave processing of gas silicate concrete production;

– results of the physical and mechanical properties of gas silicate concrete;

– results of technical and economic efficiency of production of autoclaved gas-silicate concrete and its use in construction.

Scientific novelty of the thesis:

– theoretically proved and experimentally determined the possibility of obtaining structural and heat-insulating autoclave gas-silicate concrete with a density of 600-700 kg/m^3;

– found that the addition of fine ground wollastonite can significantly improve the flow characteristics of the gas silicate concrete mixture and increase the physical and mechanical properties of it;

– developed optimal compositions and process conditions for the production of gas silicate concrete ;

– found that wollastonite is resistant to an alkaline environment, and at elevated temperatures of saturated steam during autoclaving does not lose its reinforcing properties, significantly increasing the tensile strength in bending of gas silicate

concretes;

– found that high physical and technical properties of autoclave gas silicate concrete are due to the formation of predominantly stable low-basic calcium hydrosilicates.

Practical relevance of the work

The developed technology of autoclaved gas silicate concrete with the use of phosphoric slag as a binder solves important problems of national economic importance, in particular, improves the ecological situation in the region due to the disposal of the high production volume waste, reduces the cost of maintaining dumps in a proper sanitary condition, and also reduces the cost of cellular gas silicate concrete. The use of dune sand as a silica component reduces energy costs for grinding and expands the raw material base of the construction industry.

Experience in implementing the results of work in production. A pilot batch of products made of gas silicate concretes based on phosphoric slags and polymict dune sands in combination with natural wollastonite was produced.

Validity and reliability of scientific statements, conclusions and recommendations are confirmed by the basic laws of physics, chemistry of highly concentrated suspensions having the properties of elastic-viscous plastic systems and capillary-porous bodies made using modern laboratory devices and industrial plants. Autoclave treatment was performed on the latest laboratory autoclave with autoclave treatment software and the maximum parameters for steaming products at a pressure of 1.2 MPa and at temperature of 191^0C.

Approbation of the research. The research results were introduced into the educational process, namely: in lectures on the disciplines “Concrete technology”, “Designing enterprises of concrete and ceramic building materials, products and structures”, “Autoclave materials” and “Basics of technology of wall and finishing materials”, in coursework work in the disciplines “Concrete technology”, “Design of enterprises of concrete and ceramic building materials, products and structures”, “Autoclave materials” and “Basics of technology of wall and finishing materials”, in the implementation of diploma works in the disciplines “Concrete technology”, “Design of enterprises concrete and ceramic building materials, products and structures”, “Autoclave materials” and “Basics of the technology of wall and finishing materials”, in the section “Mix design of gas silicate concrete”. Based on the results of the study, a decision was obtained to 1 patent grant for a utility model. The results of the work were published in scientific and technical journals and at international scientific and technical conferences. The results were published in scientific and technical journals and international scientific technical conferences. The main scientific and technological results were reported and received a positive assessment:

- at the international scientific and practical conference “Auezov Readings - 15: Third Modernization of Kazakhstan - New Conceptions and Modern Decisions”, dedicated to the 120th anniversary of Mukhtar Omarkhanovich Auezov (Shymkent 2017, SKSU);

- at 15^{th} international scientific and practical conference “Veda a Technologie: Krok Do Buoucnosti – 2019” (Prague, 2019);

- at international scientific and practical conference "Nainovite postizheniya na evropeiskata nauka – 2019" (Sophia, 2019);

- in scientific journal "Kazakh Leading Academy of Architecture and Civil Engineering" (Almaty 2019);

- in scientific journal Vestnik KazNRTU (Almaty, 2019);

- in journal "Industry of Kazakhstan" (Almaty, 2019)

- in journal "Journal of Advanced Concrete Technology (Japan)", ISSN:1346-8014 from the list of publications included in Web of Science Core Collection and Scopus citation databases.

Publications of the research results. The results of the dissertation are reflected in 9 publications, including one article in a journal from the list of publications included in the Web of Science Core Collection and Scopus citation databases, in two articles of the international scientific and practical conference, in two articles in non-CIS journals, in one article in the scientific journal "Vestnik KazNRTU", in two articles in the scientific journal Vestnik KazGASA, in the journal "Industry of Kazakhstan", recommended by Committee on the Control of Education and Science of the Republic of Kazakhstan for publishing the results of dissertations, obtained positive decision for patent grant.

The structure and scope of the thesis. The thesis consists of five main parts, conclusions and recommendations, a list of references and appendices. The main content of this work is presented on 136 pages and includes 36 figures, 31 tables and references 163 titles.