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DEVELOPMENT OF TECHNOLOGIES FOR THE PRODUCTION OF LIGHTWEIGHT CONCRETE AND WALL MATERIALS IN THE CONDITIONS OF THE REPUBLIC OF UZBEKISTAN

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Annotation: *This article explores the development of technologies for producing lightweight concrete and wall materials in the climatic and economic context of the Republic of Uzbekistan. The research highlights the advantages of lightweight concrete—its reduced density, high thermal insulation capacity, and ability to improve structural and energy efficiency in buildings. Comparative analysis of autoclave and non-autoclave curing methods demonstrates differences in strength, production costs, and energy consumption, emphasizing the feasibility of both approaches for industrial and small-scale production.*

The study integrates international experience from leading construction industries in Germany, the USA, Japan, China, and Russia, focusing on innovations such as 3D concrete printing, nanomodified mixtures, digital process control, and the reuse of industrial waste. The availability of local raw materials, including cement, lime, quartz sand, perlite, fly ash, and metallurgical slag, provides a solid foundation for sustainable domestic production. The implementation of advanced technologies and the use of local resources are identified as key factors for enhancing energy efficiency and promoting environmentally friendly construction in Uzbekistan.

Keywords: *lightweight concrete, aerated concrete, foam concrete, wall materials, energy efficiency, sustainable construction, autoclave technology, innovative technologies, local raw materials.*

Introduction

The development of the construction industry of the Republic of Uzbekistan requires the introduction of new materials that ensure high energy efficiency and durability of buildings. In the context of a sharply continental climate and increased energy consumption, the production of lightweight concrete and wall materials based on them is gaining particular importance.

Lightweight concrete with low density and good thermal insulation properties allows for a reduction in foundation load, a reduction in cement and steel consumption, and a comfortable microclimate within buildings. Utilizing local raw material resources (expanded clay, vermiculite, perlite, ash) creates prerequisites for organizing widespread industrial production and addressing environmental issues.

Methods of making lightweight wall materials

- Based on porous aggregates - expanded clay concrete, perlite concrete, vermiculite concrete.
- With gas and foaming agents - aerated concrete and foam concrete.
- Autoclave processing - obtaining durable and long-lasting products.
- Combined technologies - the use of several methods simultaneously.

Technology of lightweight concrete and wall materials production

The production process includes several stages.

Raw material preparation

- Drying and sorting of porous aggregates.
- Dosing of cement, sand, water, and chemical additives.
- If necessary, crushing of large fractions.

Mixture preparation

- Mixing cement, aggregates, and water.
- Introduction of modifying additives.
- For aerated concrete - adding aluminum powder, for foam concrete
- generating a ready-made foam.

Molding of products

- Pouring the mixture into molds.
- Vibration compaction (for expanded clay concrete).
- For aerated concrete, the massif is cut into blocks.

Autoclave hardening method

Applied for aerated concrete. Heat treatment with saturated steam at 180-200 °C and a pressure of 0.8-1.2 MPa provides accelerated strength gain and minimal shrinkage. Advantages: high strength, stable quality. Disadvantages: high energy intensity, equipment cost.

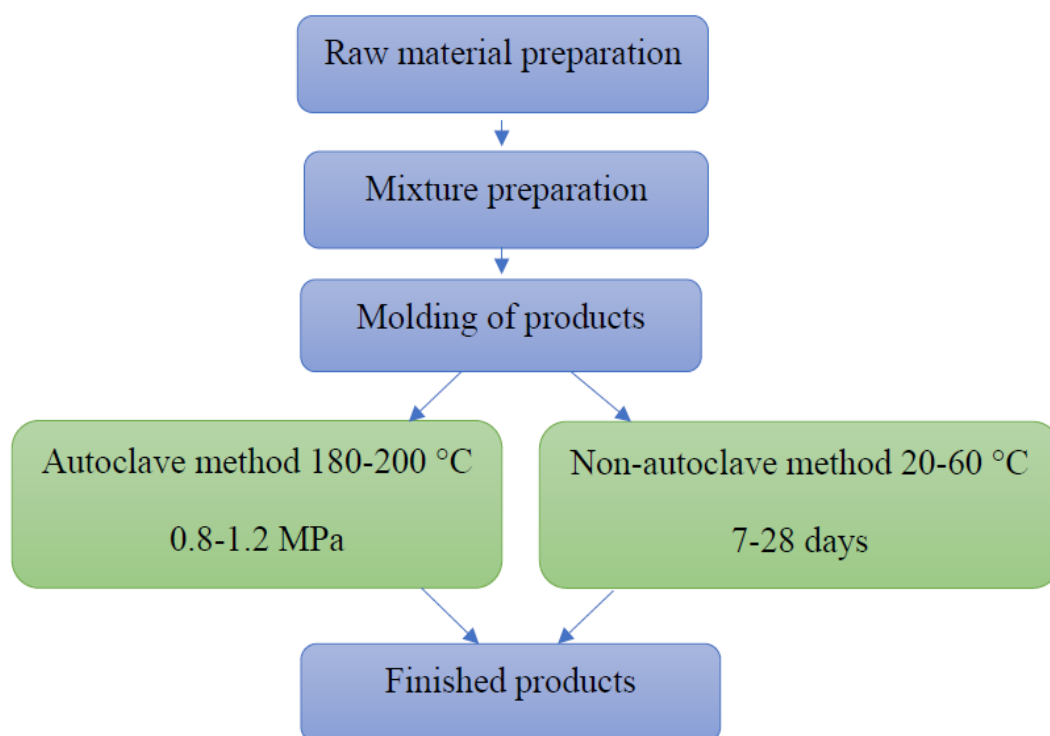
Non-autoclave hardening method

It is used for foam concrete, expanded clay concrete, and vermiculite concrete. Hardening occurs under natural conditions or during steam-heat treatment under atmospheric pressure. Advantages: technology simplicity, low cost. Disadvantages: lower strength, longer setting time.

Comparison of autoclave and non-autoclave methods

Indicator	Autoclave method	Non-autoclave method
Hardening conditions	180–200 °C, 0,8–1,2 MPa	20–60 °C, atmospheric pressure
Strength gaining time	12–18 hours	7–28 days
Compressive strength	2,5–3 times more	Below, sufficient for low-rise construction
Shrinkage and cracking	Minimum	More expressed
Energy intensity of production	High	Low
Equipment cost	High	Low
Production scale	Large factories	Small and medium-sized enterprises
Application	Bearing walls	Low-rise construction

Figure 1 - Diagram of the technological process for producing lightweight concrete.



Experimental data

Concrete type	Density, kg/m ³	Strength, MPa	Thermal conductivity, W/ (m·°C)	Water absorption, %
Heavy concrete	2400	35,0	1,75	4,2
Ceramzit concrete	1450	15,5	0,55	10,8
Perlite concrete	1050	9,2	0,32	14,5
Vermiculite concrete	950	8,7	0,28	16,0
Foam concrete	700	4,5	0,20	18,3

International experience and innovative technologies for the production of lightweight concrete

In global construction practice, the production of lightweight concrete is considered one of the key areas for increasing energy efficiency and environmental friendliness of buildings. The development of technologies is largely determined by national energy-saving strategies and the reduction of the carbon footprint in construction.

Europe

- Autoclaved aerated concrete (Germany, Sweden, Poland) accounts for up to 40-50% of the wall materials market.

- High-precision automated lines are used, allowing the production of products with minimal geometric tolerances (up to ± 1 mm), which ensures a reduction in the cost of masonry mortars and insulation.

- Innovations: use of finely dispersed additives (microsilica, nanomodifiers), as well as technologies for secondary processing of gas-concrete block waste as raw materials.

USA and Canada

- Development of high-strength lightweight concrete using artificial porous aggregates and microspheres.

- Using fibrous reinforcement (glass, basalt, and polymer fibers), which allows for increased crack resistance and durability of structures.

- Innovations: 3D printing with lightweight concrete mixtures for low-rise construction and individual house construction.

Japan and South Korea

- The main focus is on the disposal of industrial waste (ash, slag, sludge).

- Self-compacting lightweight concrete technologies are being implemented, which allows for improving the quality of formwork filling without vibrating equipment.

- Innovation: development of mixtures using nanotechnologies and functional additives that ensure high seismic resistance of structures.

China

- The world's largest gas concrete producer - more than 300 factories.
- The main direction is the large-scale use of autoclave aerated concrete in housing construction, including high-rise buildings.
- Innovations: implementation of digital technologies in quality control (online monitoring of production parameters), as well as the use of automated robots in cutting and autoclave lines.

Russia and CIS countries

- Keramzit concrete and aerated concrete technologies based on local raw materials have become widespread.
- Research is being conducted on the application of combined technologies, including the use of porous aggregates in conjunction with gas-forming additives.
- Innovations: development of concrete using nanomodifiers, improved superplasticizers, and complex mineral additives.

Innovative directions in lightweight concrete technology

1. 3D concrete printing - the development of digital construction, allowing for the production of building walls without traditional formwork.
2. Nanotechnology - the introduction of silicon dioxide nanoparticles, graphene, and other modifiers to increase strength and durability.
3. Self-sealing lightweight concretes (SCLWC) - allow obtaining products without applying vibration.
4. Composite reinforcement systems - the use of basalt and polymer fibers instead of traditional reinforcement.
5. Waste utilization - using ash, blast furnace slag, and phosphogypsum as active mineral additives.
6. Energy-efficient hardening technologies - replacing energy-intensive autoclave processes with more щадящие methods using hardening accelerators and low-temperature treatment.

Thus, international experience shows that the prospects for the development of lightweight concrete are linked to the digitalization of production, the application of nanomodifiers and industrial waste, and the transition to environmentally safe technologies. For Uzbekistan, the implementation of autoclave technologies for aerated concrete, the development of 3D printing, and the use of local technogenic waste as a mixture are most relevant.

Raw material base of the Republic of Uzbekistan for the production of foam concrete and aerated concrete

1. Basic binding materials

- Portlandcement-is a key component for foam concrete and aerated concrete. It is produced in Ohangaron, Bekabad, Kuvas, Navoi, and other cement plants in the country. The availability of cement ensures the stability of supply for large and small production.

- Lime - is widely used in the technology of autoclave aerated concrete. Large reserves of limestone are found in Tashkent, Fergana, Jizzakh, and Navoi regions. In production, ground and hydrated lime is used.

2. Siliceous components

- Quartz sand is the main source of silica in autoclave aerated concrete. Large deposits are located in the Tashkent, Navoi, and Bukhara regions. Sand is pre-ground to a finely dispersed state.

- Perlite sand - there are industrial perlite deposits in Uzbekistan (Bukhara, Kashkadarya regions). It can be used as an alternative to quartz sand to obtain lighter mixtures.

3. Gas and foaming additives

- Aluminum powder and paste - used for aerated concrete. Upon interaction with calcium hydroxide, hydrogen is released, forming a porous structure. In Uzbekistan, aluminum powder is not yet produced on an industrial scale, therefore it is imported from Russia, Kazakhstan, and China.

- Foaming agents (synthetic and protein) - used in the production of foam concrete. Uzbekistan mainly uses imported reagents (Russia, China), however, local production of foaming agents based on protein hydrolysates is developing.

4. Mineral and technogenic additives

- TPP ash is a promising additive for aerated concrete and foam concrete. It improves pore formation and reduces cement consumption. The main volumes of fly ash are formed at the Novo-Angren, Talimarjan, and Navoi Thermal Power Plants.

- Metallurgical production slags - in their ground form, they are used as an active mineral additive that increases the strength and durability of products.

- Phosphogypsum is a by-product of the chemical industry. It is used as a substitute for natural gypsum to regulate the setting times of gas-concrete mixtures.

Conclusion

The development of lightweight concrete and wall materials production in the Republic of Uzbekistan is a strategically important direction in the construction industry. It combines the solution of several key tasks at once: reducing the energy intensity of construction, ensuring a comfortable and healthy microclimate in buildings, rational use of natural and technogenic resources, and reducing the environmental burden.

The analysis showed that the republic has a rich raw material base for the production of lightweight concretes, including expanded clay, perlite, vermiculite, as well as significant volumes of ash and slag from industrial enterprises. Cement, lime, and quartz sands, which are widespread in the country, are particularly important for the production of foam concrete and aerated concrete. This creates conditions for organizing local production, reducing import dependence, and providing the construction industry with high-quality materials.

International experience shows that autoclave technologies for producing aerated concrete are gaining the most development, ensuring stable quality and high strength of products. At the same time, the development of non-autoclave methods,

allowing for the organization of small and medium-sized enterprises with minimal capital investments, is also promising for Uzbekistan. Such a combination allows for a flexible response to the needs of the construction market, encompassing both large industrial and low-rise housing construction.

Special attention should be paid to energy saving issues. In a sharply continental climate, the reduction of heat loss in buildings directly affects the consumption of natural gas, which forms the basis of the country's energy balance. The use of structural-heat-insulating concretes can significantly reduce fuel consumption and CO₂ emissions, which fully corresponds to the Strategy for the Transition of the Republic of Uzbekistan to a "green" economy.

For the successful development of the industry, it is necessary:

- improvement of the regulatory framework and implementation of modern quality standards;
- state support for innovative technologies and attracting investments to production;
- expanding research in the field of selecting optimal compositions of mixtures and utilizing local raw materials;
- development of local production of aluminum powder and foaming agents, which will reduce import dependence;
- stimulating the use of lightweight concrete in mass housing and industrial construction.

Thus, the production of lightweight concrete and products based on them should be considered not only as a technological direction but also as an important element of the national program for increasing energy efficiency, sustainable socio-economic development, and transition to environmentally safe construction.

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