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ENERGY-EFFICIENT NON-AUTOCLAVE AERATED CONCRETE BASED ON LOCAL SILICA RAW MATERIALS FROM PRODUCTION WASTES

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ЭНЕРГОЭФФЕКТИВНЫЙ НЕАВТОКЛАВНЫЙ ГАЗОБЕТОН НА ОСНОВЕ МЕСТНОГО КРЕМНЕЗЕМИСТОГО СЫРЬЯ ИЗ ОТХОДОВ ПРОИЗВОДСТВА

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Abstract. Presents the results of studies (research) on the use of silica raw materials from the production waste of refinement tailings of antimony ores (or antimony ores refinement tailings) and basalt fiber waste, their influence on the quality characteristics of non-autoclave aerated concrete.

Аннотация. Приводятся результаты исследований применения кремнеземистого сырья из отходов производства хвостов обогащения сурьмяных руд (ХОСР) и отходов базальтовых волокон, их влияния на качественные характеристики неавтоклавного газобетона.

Keywords: non-autoclave, technogenic material, silica fillers, energy efficiency.

Ключевые слова: неавтоклавный, техногенный материал, кремнеземистые наполнители, энергоэффективность.

The implementation of energy saving construction material new types into the national economy that most fully meet the requirements of modern construction is one of the construction complex sectoral tasks. These construction materials include non-autoclaved aerated concrete products. Due to their environmental safety, high thermal insulation capacity and reduced energy consumption in comparison with autoclaved aerated concrete products. Kyrgyzstan has significant reserves of sandy rocks, fine-grained sands and man-made materials that can be used in the production of non-autoclaved aerated concrete products. In relationship with the above mentioned, it is very relevant to create and develop of a non-autoclave aerated concrete products based on local silica-containing natural and man-made raw materials. This will significantly improve the characteristics and reduce the key technical and economic indicators (values) of their production [2-7].

Research goal is to study the effect of silica filler types from production wastes on the quality characteristics of non-autoclaved aerated concrete and products based on them. For the study (research) performance, Portland cement M400 D20 grades in accordance with GOST 3108-2016 “Common cements. Specifications”; II grade Lump quicklime: content of active CaO and MgO — 82%, amount of unquenched particles — 1.2, calcium chloride ($CaCl_2$) as a hardening accelerator in accordance with GOST 450-77 “Calcium chloride for industrial use. Specifications”.

Refinement tailings of antimony flotation ores and of basalt fiber wastes were used as a filler.

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Antimony ores refinement tailings is formed during the production of antimony from rocks after their heat treatment at 1200 °C. Chemical composition is represented by the content in %: SiO_2 — 70.93; CaO — 12.67; Fe_2O_3 — 0.73; Al_2O_3 — 6.92; MgO — 0.03; SO_3 — 0.82; R_2O — 0.67; P.P.P. — 7; mineralogical composition — contents-quartz, calcite ($CaCO_3$) and an insignificant amount of clay components (Al_2O_3 = 6.92%).

Antimony ores refinement tailings is characterized by easy grindability, and grindability factor is 1.2 (ratio of the time required for grinding quartz to the time required for grinding a given material to the same degree of fineness).

Dispersed waste from the basalt fiber production located in Chui region of the Kyrgyz Republic was used as a reinforcing additive. Chemical composition of the filler — waste fibers of mineral wool production of Fakel OJSC in %: SiO_2 — 52.67; Al_2O_3 — 12.14; Fe_2O_3 — 6.97; CaO — 13.92; MgO — 9.06; SO_3 — 0.65; R_2O — 4.7; P.P.P. — 4.41. Mineralogical composition in %: SiO_2 — 59.01; Al_2O_3 $2SiO_2$ $2H_2O$ — 31.67; $CaSO_4$ — 0.68; $CaCO_3$ — 1.03; $MgCO_3$ — 5.98; P.P.P. — 4.41 = 2200-2250 cm^2/g. Aluminum powder of PAP-2 grade in accordance with GOST 5494-81 “Pigmentary aluminum. Specifications”.

Compositions containing refinement tailings of antimony ores, waste basalt fiber, quicklime, calcium chloride, aluminum powder were tested to obtain non-autoclaved aerated concrete, from which an aluminum suspension was preliminarily made. Table presents specific compositions and properties for obtaining non-autoclaved aerated concrete.

All components were loaded into water and mixed. Resulting mixture was poured into molds with dimensions as 10×10×10 cm, kept, and top was cut off. Molds were removed after 48 hours, after which the non-autoclaved aerated concrete samples were placed in a normal hardening chamber. After 28 days, the physical and mechanical properties of the samples were determined. Test results of the samples are shown in Table.

Table

MAIN COMPOSITIONS AND PHYSICAL – MECHANICAL PROPERTIES
OF NON-AUTOCLAVED AERATED CONCRETE

Composition components, mass, %	*Average density, kg/m^3*	*Compressive limit strength, MPa*		*Constructive quality factor, k.k.k = R/ρ^2*
		7 days	*28 days*	
Portland cement — 15.0; Refinement tailings of antimony ores — 30.0; Basalt fibers — 1.0; Quicklime (CaO) — 8.0; A1-powder — 0.08; Calcium chloride (CaCl) — 0.13; Water — 45.8	520	1.4	1.6	5.9
Portland cement — 20.0; Refinement tailings of antimony ores — 35.0; Basalt fibers — 2.0; Quicklime (CaO) — 10.0; A1 – powder — 0.06; Calcium chloride (CaCl) — 0.16; Water — 32.8	625	1.7	2.2	5.6
Portland cement — 15.0; Refinement tailings of antimony ore — 30.0; Basalt fibers — 2.0; Quicklime (CaO) — 8.0; A1-powder — 0.08; Calcium chloride (CaCl) — 0.13; Water — 44.8	500	1.2	1.5	6.0

Table data present that non-autoclaved cellular concrete of the proposed composition meets the requirements in accordance with GOST 25485-89 “Cellular concretes. Specifications” and has a grade of average density D500, D600, compressive strength class B1, B1.5, respectively. Energy efficiency of the aggregate grinding operation from the refinement tailings of antimony ore wastes, use of cheap fibrous basalt wastes and a decrease in the Portland cement proportion regarding the mixture composition can reduce the cost of non-autoclaved aerated concrete by 15%, simplify the technology and accelerate the production process of its manufacture while ensuring the standard characteristics.

Implementation of basalt fiber waste in an amount of 1.0-2.0% allows, without reducing the quality of the material, to strengthen and stabilize the macrostructure of non-autoclave aerated concrete, to increase the stability of the gas mass before the setting of the binder begins, to improve the strength and deformation properties of a material.

With the content of Portland cement in the raw mixture composition, used as a binder at a ratio of 15.0-20.0% can be optimal, since at less than 15.0%, insufficient strength of aerated concrete products is formed. At more than 20.0%, the average density of products increases.

Presence of quicklime increases the alkalinity of the liquid phase, which improves gas formation and swelling of the raw mixture and contributes to the strength characteristics of aerated concrete. In turn, this is due to the fact that the refinement tailings of antimony ore wastes contained in the composition (SiO_2 — silica) are in an amorphous state, respectively, absorbing free lime (CaO) in the mixture with the formation of calcium silicate (tobermorite).

If the content of refinement tailings of antimony ore wastes is less than 30.0%, shrinkage deformations appear, leading to a decrease in strength and frost resistance. If the content of refinement tailings of antimony ore wastes is more than 35%, the strength of aerated concrete becomes below the level allowed by the standards.

If the content of basalt fiber wastes is less than 1.0%, the sufficiency of improving the strength and deformation characteristics of concrete. If the content of fibrous basalt wastes is more than 2.0%, its uniform distribution in the mixture becomes difficult, and the structure of aerated concrete is characterized by the presence of large pores and voids.

If the content of aluminum powder is less than 0.06%, aerated concrete does not reach the specified porosity, which leads to an increased average density. If the content of aluminum powder is more than 0.08%, an excess amount of hydrogen is formed, which leads to the coalescence of gas bubbles and their tearing out through the surface, as a result of which the aerated concrete mixture shrinks.

If the content of calcium chloride is less than 0.13%, the effect of accelerating the hardening of aerated concrete is not ensured. Aerated concrete mixture settles after the completion of the swelling process. If the content of calcium chloride is more than 0.16%, the effect of accelerating the hardening is slowed down and further increase is not effective.

Based on the research results, a patent for the invention of the Kyrgyz Republic no. 2261 “Non-autoclaved cellular concrete” was obtained [1].

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