Effective Aerated Concrete for Energy Efficient Construction

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Abstract – The article analyzes methods of improving quality indicators of aerated concrete. It is shown that nanotechnological control of cementitious systems containing fine mineral additives create opportunities for efficient production of aerated concrete with improved performance.

Key words – aerated concrete, non-autoclaved curing, ultrafine supplementary cementitious systems, energy efficiency, durability.

I. Introduction

Current requirements for energy efficient operation of residential and civil buildings provide the development and use of aerated concrete with high heat-resistance properties and performance for wall construction. In the structure of energy consumption of Ukraine more than 40% of energy used in the residential sector to the needs of providing optimum microclimate. In this regard, the most important strategy for housing policy is new energy efficient construction and affordable housing, upgrading and reconstruction of housing, obtaining additional accommodation within existing buildings, which determines the need to improve the efficiency of construction of the walls by the development and use of new advanced materials with high thermal insulation properties as high strength and durability, including aerated concrete, constructive solutions and improvement of their application in order to minimize energy consumption and material resources in the operation of buildings and reduce the negative impact on the environment.

The reduction of the clinker is now also being driven to a great extend by the use of supplementary cementitious materials (SCM) [1]. In most SCM are represented by industry waste products, such as fly ash, slag, silica fume or other natural materials such as quartz sand, limestone and others. In some cases the process of mechanical activation can significantly influence on the properties of ultrafine supplementary cementitious and thus, on the building and technical properties of binders [2]. It is shown while the grinding of particles to nanoscale structure the superficial energy is similar to volume energy and then superficial atoms obtain more substantial influence on the synthesis of the cementitious systems strength. The nanotechnological manipulation and control of properties cementitious systems with fine ground mineral additives give the possibility of producing new kinds of sustainable concretes [3]. Considerable interest for the future investigations study is a byproduct of coal burning – fly ash [2]. The pozzolanic activity of fly ash measures the ability to react with calcium hydroxide and depends on the content of reactive silica or alumina, the grain size and state of the material (glass content, metastability) [3].

II. Recent research and publications

According to the trends in the use of modern building materials for the construction of external walling residential and public buildings that meet energy efficiency becoming more common effective constructional and insulating materials such as aerated concrete to the advantages which include high heat-shielding properties sufficiently high strength and durability. Share of aerated concrete in wall materials market in the EU is 60%. Analysis of aerated concrete sales volumes in Ukraine for 2000-2015 years shows a steady growth trend of using this material in recent years, including the 2009 aerated concrete market grew three times with 700-800 thousand m$^3$ to 2.4 million, m$^3$, but its share in the production of wall materials is only 18%

Aerated concrete is a material for walling low-rise and high-rise building framed by allowing changes to its rather wide range of medium density, thermal conductivity and strength, which is important for solving various design problems in building. The use of products from aerated concrete in the building will reduce material consumption, improve energy efficiency, insulation and aesthetic characteristics of buildings and reduce the cost of housing [4].

Production of aerated concrete is autoclaved and mainly based on the method of heat treatment, providing the required properties. However, this production method is characterized by high energy costs, and selling aerated autoclave humidity is 20-37%, which leads to increased heat and require the use of permeable plasters for walls of concrete blocks [5]. Autoclaved aerated concrete is also characterized by low fracture toughness and resistance to frost.

The development of modern building technology in all the technically advanced countries is aimed at the development of building materials, the use of which is economical, and can reduce the costs of energy and raw materials. Therefore, the interest in non-autoclaved aerated concrete, due to the relatively simple technology of production, widespread raw materials and low energy consumption is growing each year. However, the main disadvantage of non-autoclaved aerated concrete is low degree of binder hydration, which significantly complicates and makes more expensive its production due to increased cement consumption to achieve similar performance. Relatively high rates of physical and mechanical properties of non-autoclaved aerated concrete curing provided only for products with an average density of concrete above 600 kg / m$^3$ (D 600), which causes increased thermal conductivity. Due to the intensive development of frame-monolithic construction and increased requirements for thermal properties walling research aimed at developing formulations and technologies non-autoclaved aerated concrete with an average density of 500 kg/m$^3$ and below. The disadvantages of non-autoclaved aerated concrete also include a large shrinkage (2.3 mm / m), which is the result of lower hydration crystallisation products, lower strength at the same density products compared to autoclave concrete.

III. Methods of improvement of nonautoclaved aerated concrete parameters

Concrete mixture for the production of aerated concrete should be characterized by high gas ability, optimal
setting time, which together provide the optimum porous structure and high quality of finished products. The main factors affecting on properties of aerated concrete is their component composition, the amount of pore space, pore size and their distribution and strength of partitions between pores.

The basis of modern concrete technology is based on creating high-quality artificial stone, which has high dispersion, low defects and constancy structure on which can be created on purpose different concrete by introducing additional components of the structure and its modification. In order to regulate the rheological and physical and mechanical properties of the material in a wide range of the binder injected chemical and mineral admixtures, including waste production. For activation of wide range of the binder injected chemical and mineral physical and mechanical properties of the material in a modification. In order to regulate the rheological and chemical activity, so that can fundamentally change the processes of synthesis of structure. The presence in the system micro- and nanoparticles of mineral additives and fillers will significantly change the structure formation processes of cementitious systems [1].

Before synthesized nanoscale modifiers include Carbon Nano modifiers including: fullerenes, single and multiwall nanotubes and others. use of carbon nano-particle technology as the basis ECOCON nanoaerated concrete characterized by improved microstructure and increase in strength by 30% compared to the unmodified [3]. However, it does not solve the problems of uniform distribution of carbon nano modifiers among the cement matrix due to their increased susceptibility to agglomeration, it is not high enough coupling the nanotubes with a matrix that does not fully use their high modulus of elasticity and methods of synthesis of nanomaterials require expensive as specialized equipment and highly qualified staff, which greatly affects the growth of their cost [5].

In non-autoclaved aerated concrete technology based mixtures with high flowability (W/B= 0.6-0.8) in the injection mode, the role of crystal component that filling the pores, causes increase of strength in the initial period and reduces shrinkage deformation in products. As a result of the exchange reaction when entering the complex supplementary cementitious materials based on lime and sodium sulfate forming fine colloidal gypsum, thus there hydration lime with the formation of lamellar crystals Portlandite can positively affect on the processes of gassing, swelling and structure of the acceleration of hardening, the plastic strength and decreasing of shrinkage.

**Conclusion**

The positive impact of nanoparticles on microstructure and properties of cement materials caused by different factors: the dispersed ultrafine and nanoparticles increase the viscosity of the liquid phase, sedimentation and improves the stability of the mixture; nanoparticles act as crystallization centers hydrates, they accelerate the process of hydration; positive affect on the formation of small alumoferrite crystallites and increase uniformity hydrosilicates; involved in pozzolanic reactions leading to formation of Ca(OH)₂ and the additional quantities of C-S-H; improve the structure of the transition zone between cement matrix and filler; provide the reduction of cracking, increase hardness, strength of effective aerated concrete for energy efficient construction.

**References**


