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Research into Influence of Ultra- and Nanodisperse Size Additives on the Structure and Properties of Heat Insulating Autoclaved Aerated Concrete

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Abstract

The paper presents the results of the research into the influence of various ultra- and nanodisperse size additives on the structure and mechanical-and-physical properties of heat insulating autoclaved aerated concrete (AAC). Research into interaction mechanisms of such additives as silica gel, high active metakaolin and multi-walled carbon nanotube dispersion (MWCNTs) with heat insulating AAC components consisted in the evaluation of the dynamics of the cellular concrete plastic strength increase of porous mixture, degree of cellular concrete blowup and comparing the strength and density of the check sample and the modified one. The studies found that the most effective method of obtaining the structural strength of AAC is by the use of the MWCNTs. They contribute to obtaining the optimum viscoplastic properties of bulk concrete and stabilizing of the pore formation process with simultaneous formation of the solid homogeneous hexagonal structure.

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1. Introduction

One of the most important directions in the modern building material science is development and introduction of new effective heat insulating materials, which is mainly due to the growth of electricity rate and cost of energy needed for heating of buildings. As for the energy efficiency, increasingly stringent requirements to the thermistance of enclosing structures and controlled environment improvement in buildings are worth mentioning. Autoclaved aerated concrete (AAC) with low density is an example of the material with efficient thermal characteristics. Insufficient structural composite strength at low values of its average density is a major obstacle to the wide use of this material as heat insulation [1,2,3].

A solution to the problem is the use of ultra- and nanodisperse size additives, which can influence the mineralization processes and increase the structural strength of AAC interporous walls [4].

The use of fine ground mineral additives, which act as crystallization centers of new growths in AAC, is the most common way of structuring aimed at binding the hydration hardening [5,6]. Ultrafine additives containing active micro-silica (silica gel) are of great current interest [7,8,9]. Another active mineral additive commonly used to increase the physical and mechanical characteristics of concretes is high active metakaolin [10,11].

Works by Russian and foreign researchers on the possibility of significant change in the strength characteristics of concrete with different density through the use of multi-walled carbon nanostructures in ultralow doses (0.002-0.005% by the weight of the binder) are known [12,13,14].

However, the efficiency of the modifiers described above was в evaluated in relation to either heavy cement concrete or cellular concrete with average density of 500 kg/m^3.

Thus, research into the influence of ultra- and nanodisperse size additives on the processes of structure formation and improvement in the physical and mechanical characteristics of low density AAC (250 kg/m^3 or less) is relevant.

2. Materials and methods of research

To obtain heat insulating AAC, cement CEM I of 32,5-42,5 class (GOST 31108) produced by OAO "Gornozavodskcement"; 2nd grade lump lime by OAO "PZSP": (GOST 9179); quartz pit sand (Proletarskoe field, Perm) containing unbound SiO_2 of no less than 85% (GOST 8736); water from the central water source (GOST 23732) were used. "Stapa Alupor N905" specialized blowing agent manufactured by "Eckhart" corporation (Germany) was chosen as a pore agent [2]. Superplasticizer based on "Melflux 5581F" polycarboxylate esters produced by "BASF Construction Polymers" corporation (Germany) was used to reduce the water content and stabilize viscoplastic properties of the aerated concrete mix.

To improve the structural strength of the heat insulating AAC, the following ultra- and nanodisperse size additives have been used:

- *The silica gel* (SiO_2), produced by OAO "Ammophos" (Cherepovets, Vologda region). The silica gel is produced as a result of hydrofluosilicic acid reaction with aluminum hydroxide at the temperature of 90-95°C in the process of aluminum fluoride manufacture. High activity of silica gel is due to the content of active silica particles characterized by high specific surface (S = 15000cm^2/g) and high reactive capacity.

Based on the literature data and the results of this additive testing on cementation systems [7,9,15], when selected, the working range of varying dosages of silica gel was taken from 4% to 10%.

- *The* "HAM-40" h*igh active metakaolin*, manufactured by "Synergy" mining company, (Magnitogorsk, Chelyabinsk Region). It is a product with high pozzolanic activity and maximal (97-99%) amorphization aluminosilicate structure. As for the granulometric composition, the "HAM-40" is powder with the average particle diameter of less than 15 microns for 50% volume product weight. The mass fraction of particle size less than 2 microns is 20%. The metakaolin used has a high whiteness and a high specific surface (S = 13000 cm^2/g). Based on data in the literature [10,11] and the recommendations of the manufacturer, the dosage range is taken from 4% to 10%.