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Development of microstructure of the fly ash aerated concrete in time

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Abstract

Calcium hydro-silicate components formed during the autoclaving process are highly complex formations which often blend together mutually and form a variety of intermediate products, from completely amorphous, to the good crystalline phases. For fly ash autoclaved aerated concrete, the situation is even more complicated by the fact that high temperature and fluidized fly ash, as basic silica ingredients, have high variability of the chemical and mineralogical composition. This paper presents the results of microstructure monitoring and physical and mechanical tests on samples of fly ash aerated concrete based on high temperature and fluidized fly ashes performed after 2 years of storage in laboratory conditions. The microstructure of aerated concrete is assessed on the basis of SEM images and mineralogical composition according to X-ray analysis. The changes in compressive strength, density and coefficient of thermal conductivity of the fly ash aerated concrete in time are evaluated.

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1. Introduction

Aerated concrete is a building material which possesses an array of physical-mechanical properties that would otherwise require an appropriate combination of several types of materials. Its universality lies in low bulk density combined with sufficient structural strength. The low bulk density is due to the porosity of the material, structural

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strength is determined by a very strong crystalline structure of the inter-pore walls. Calcium hydro-silicate based aerated concrete, where the pores represent approximately 50 % of volume, is due to its structure an excellent thermal insulation material. Structures from aerated concrete mostly meet the thermal-technical requirements of contemporary standards without any additional insulation. The homogeneity of aerated concrete walls (as opposed to structures with external thermal insulation) has a positive influence on thermal transmittance and steam and air flow, as reported by Brandštet and Šauman [3]. The durability of aerated concrete is understood as its resistance to weather and other external attack and to ageing, fatigue and wear. Specifically, the durability of aerated concrete is understood as frost and weather resistance, investigated Drochytka [2].

Much like in ordinary concretes, carbonation occurs in autoclaved aerated concretes during exposure to CO₂ as well. However, there are some differences in the reactions taking place. It was also proposed by Matsui, et al. [5], that at the very beginning of carbonation reactions in aerated concrete, CO₂ reacts with calcium hydro-silicates and calcium hydro-aluminates present which is facilitated by the fact that the inter-grain space has a greatly reduced pH value due to autoclaving and the hydrothermal reactions which occurred there. The reaction kinetics of the minerals in aerated concrete with CO₂ can be represented by the equation (1).



According to Matoušek and Drochytka [1], another difference lies in the fact that in autoclaved materials all products of hydrothermal reactions are typically well crystalline which slows down the reaction with CO₂. Moreover, it has been observed that aerated concretes do not carbonate completely but only to a degree of 40 to 55 % which is, among others, caused by changes in moisture conditions of structures made of aerated concrete, i.e. very high or very low moisture.

Table 1. Classification of aerated concrete in 2 phases of carbonation.

Phase of carbonation	Carbonation degree [%]	pH [-]	Condition of carbonation
I	≤ 35	≥ 9.2	initial
II	> 35	< 9.2	advanced

Carbonation in aerated concrete takes place only within a specific interval of material moisture, i.e. when initial moisture has dropped below 20-25 % and the aerated material has not yet dried to 4-6 % of moisture content. Carbonation is at its most intense within this interval. However, the decrease in strength after the carbonation of aerated concrete is negligible; a greater risk lies in the action of SO₂, i.e. sulphation. The knowledge of the influence of moisture on the carbonation of aerated concrete applies to sulphation as well; in fact, these degradation processes typically occur simultaneously.

2. Experimental program

2.1. Raw materials and specimens production

The silicate component in the aerated concrete was a mixture of 2 high-temperature fly ashes (HTC1 and HTC2) and 1 fluidized bed combustion ash (FBC). Their chemical composition is listed in Table 2. Specimens contains 0 % (0 FBC) and 13 % (13 FBC) admixture of FBC. Lime was used as binder together with flue gas desulphurization gypsum as an auxiliary raw material. The raw materials were mixed in a mixer with water at 50 °C, concrete sawing sludge and aerating agent. Aluminium powder was used as the aerating agent. The slurry was poured in moulds in which the concrete was left to expand and later to cure. After 2 – 3 hours the aerated concrete cake reached manipulation strength and it was possible for it to be cut into blocks. These were then autoclaved in saturated steam for 12 hours at the temperature of 174 °C and pressure of 0.8 MPa. In these conditions a

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