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Short Communication

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Porous materials based on liquid glass

Abstract

This article studies cement-free heat insulating alkaline silicate compositions based on technogenic raw stuff. The influence of technogenic factors on aeration of compositions made of liquid glass and technogenic filler has been detected.

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Introduction

The efficiency of using liquid glass as a matrix of astringent compositions is known.[1–7] As the filler of liquid-glass binders, it is expedient to use technogenic materials containing at least 35–40% silica. Technogenic materials consisting of amorphous silica (for example, glass battles), silicates and aluminosilicates of calcium and magnesium are preferred. Liquid glass in the initial stages of the transformations serves as a catalyst for the destruction of the starting compounds. In the later stages of the process, liquid glass actively participates in the formation of a dispersive-coagulation and a conduction-crystallization structure. Liquid glass is an effective component of cellular concrete, produced using various methods of porosity. Cellular materials based on liquid glass are characterized by increased strength of the interporal partitions. There are extensive methods for the porosity of liquid-glass materials. The purpose of the work is the development of highly effective thermal insulation materials by optimizing the formulation and regulation of the formation of a highly porous combined structure of cementless alkali-silicate compositions with technogenic fillers In the work were investigated the compositions containing stellite, metallurgical slag, scrap-magnetite ore dressing wastes, granite scrap crushing wastes, and thermal power systems. It has been shown that the use of liquid glass with a density of 1250 to 1300kg/m^3 as a matrix is preferred. To stabilize the physical-mechanical properties, it is expedient to treat the compositions at a temperature of 50–100. The activating effect of glass powder on the hydration activity of silicate and aluminosilicate technogenic materials was established (Figure 1). It was suggested that reactions can proceed by dissolution and by a topochemical method. The possibility of hydromechanoactivation of alkali-silicate compositions based on wastes of ore dressing has been revealed (Figure 2). Technologically preferable parameters of hydromechanical processing are determined for the suspension state. Alkaline activation of technogenic raw materials makes it possible to involve various types of waste in the production of low-energy-intensive binders.

The effect of foaming agents of various origin on the porosity of alkali-containing solutions of NaOH (density 1200kg/m^3), Na_2CO_3 (density 1200kg/m^3) was investigated; $Na_2O(SiO_2)n$–liquid glass (density of 1250kg/m^3). A liquid glass of density 1200–1350kg/m^3 provides the required properties of foam and hardening material. The use of the protein foaming agent «Unipore» is accompanied by coagulation processes and the formation of clots in the liquid glass. Foam based on «Unipore» is heterogeneous and very unstable. The foam based on synthetic blowing agents «Fairy» and «Zelle –1» is stable, has small pores. Such foaming agents are most effective at pH =7.0–10.5. Liquid-glass compositions consist of liquid glass and technogenic filler, which affects the rheological properties and the foamability of the mass. As fillers are used: cullet, metallurgical slag, heat power ash, scrap waste from enrichment of skarn-magnetite ores. The increase in the proportion of the filler naturally increases the density of the compositions by decreasing the porosity. To obtain a foam-mass resistant to sedimentation, the ratio of «liquid glass: filler» should be considered equal to «1:1.65–1:1.85», the concentration of foaming agent is 3–4% (for example, Table 1). The structure of compositions with a density of 480–650kg/m^3 is sensitive to a change in the material composition of the molding mass. Compared with «Fairy» when using «Zelle – 1» large cells with an average size of 0.–1.0 mm are formed (Figure 3). Foam concrete based on metallurgical slag and wastes of enrichment of skarn-magnetite ores is characterized by smaller cells in comparison with the cullet-based composite (Figure 4).

For the liquid-glass compositions porosity is used hydrogen peroxide by gas formation method. Injection of 1–5 % H_2O_2 provides a composition with a density of 770–960kg/m^3. The pores are spherical and ellipsoidal in shape. An ash microsphere was introduced into the liquid-glass compositions as the porous particles. The use of hollow particles contributes to the formation of a uniform structure of composites with a density of 1320–1450 kg/m3. The microsphere content in the mixture affects the rheological properties of the molding mass and should not exceed 20%.

The results of the studies indicate that the pronounced chemical activity and the controlled density of the solutions $Na_2O(SiO_2)n$ predetermine the choice of pore-formers with high foaming power and stability in the medium of the shutter. A working hypothesis has been confirmed: cementless compositions containing as a shutter a liquid with increased density, allow the use of a wide range of technological methods for the formation of a porous structure. To improve the thermal protection properties of the compositions was investigated a combination of foam formation and gassing. Hydrogen peroxide is used as the gas converter, the concentration of which depends on the type of foam blowing agent, the composition and viscosity of the molding mixture, and the rate of structure formation. Addition 2% of H_2O_2 allows reducing the density of foam concrete from 650–700 kg/m^3 to 300–450kg/m^3. Hydrogen peroxide affects the integrity of the cell structure, often breaks the pores and forms open porosity. It was found that preheating the liquid glass to a temperature of 30–35°C and adding H_2O_2 to the total mass provide a fine uniformly distributed porosity. Foam-gas- liquid-glass compositions have a density of 410kg/m^3 and a compressive strength of 1.2MPa.

The possibility of obtaining foam-gas- liquid-glass compositions with porous particles was shown. Use of 10% hollow filler–ash microsphere allows to obtain a heat-insulating material with a fine-porous homogeneous structure. The composition has a density of 350 kg/m^3, compressive strength is 1.1 MPa (Figure 5).

Table 1 Influence of waste glass portion on properties of aerated material

Liquid glass: slag	Foam expansion ratio	Density of foam, kg/m^3	Density of foamed concrete, kg/m^3	Compression strength of foamed concrete, MPa
1: 1.45	5.1	570	400	0.8
1: 1.65	5.2	620	420	1.0
1: 1.85	5.1	640	425	1.1
1: 2.00	5.0	670	470	1.2

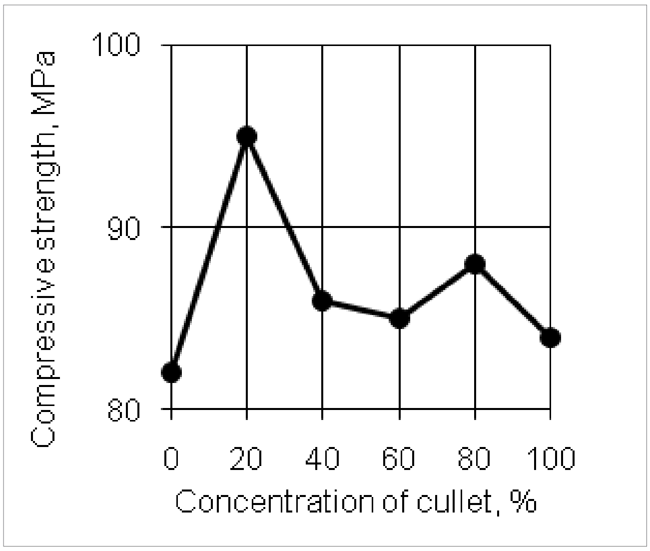

Figure 1 Effect of glass cullet on the strength of the composition from ore beneficiation wastes.

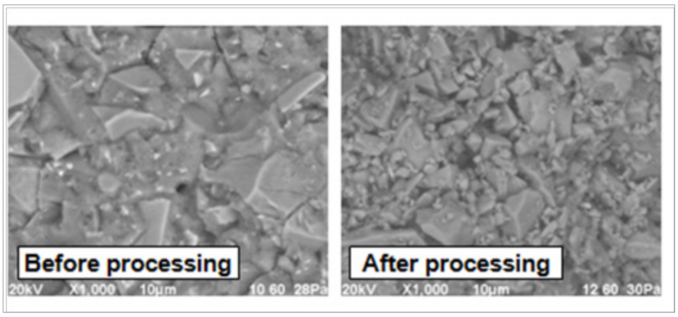

Figure 2 The influence of hydromechanoactivation on the microstructure of the composition.

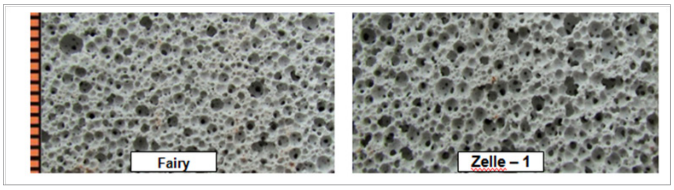

Figure 3 Structure of liquid-glass compositions on various foaming agents.

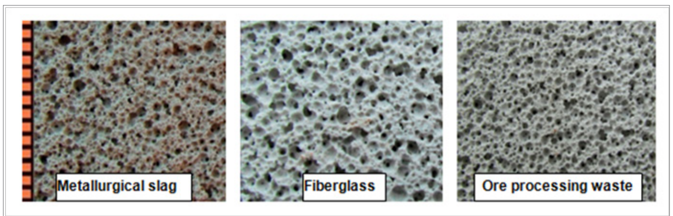

Figure 4 Structure of foam concrete is using various fillers.

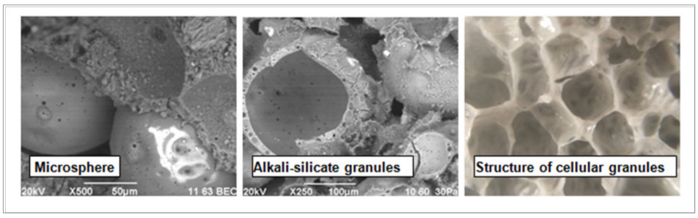

Figure 5 Microstructure of liquid-glass composition with porous particles.

Conclusion

The regulation of the composition of the components will ensure the manifestation of high hydration activity of cement-free compositions. The results of the studies confirmed the working hypothesis: a multicomponent composition of liquid-glass compositions provides opportunities for combining various methods of porosity. Combined structures based on technogenic fillers are characterized by stability and high porosity.

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None.

Conflict of interest

Author declares that there is no conflict of interest.

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