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Porous concrete based on glass-integrity binder

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Abstract
Broken glass makes up a large percentage of the industrial waste that is thrown in massive volumes into landfills. Meanwhile, it is an effective secondary resource that can be used in the construction industry to obtain binders, concrete and products based on them. Solving the problem of recycling artificial glass breakage can bring significant economic and environmental benefits. Especially now, enterprises offer cullet for next to nothing, just to get rid of it. In this regard, based on a glass-alkali binder, cellular and porous concretes capable of hardening at temperatures below 90 ° C have been developed. Effective porous concretes based on a glass-alkali binder with improved physical, mechanical, technological and operational properties have been obtained. The quantitative dependences of changes in the physical and mechanical properties of porous composites based on glass breakage under the influence of chemical and biological aggressive media have been experimentally established. The optimal technological modes of obtaining cellular and porous concretes based on a glass-alkali binder have been revealed.

Keywords: porous concrete, glass-alkali binder, autoclave-free method, expanded clay, aluminum powder

Introduction

The use of secondary material resources is one of the most important areas of energy and resource conservation in construction. Currently, the problem of the integrated use of local raw materials and industrial waste is crucial matter. This is due to the need to protect the environment, the scarcity of certain raw materials, the need to improve production efficiency. Every year, experts from various fields of science and industry pay increasing attention to the issue of utilizing technogenic waste. Considering that attitudes toward the use of so-called secondary resources in the industry are not shifting for the better, it is reasonable to assume that this problem will become ever more urgent over time. One of the main obstacles on the way to solving the above problem is the lack of a sufficient number of real projects involving the development of technologies to ensure the reuse of industrial waste in obtaining products for various purposes [1, 2].

Currently used methods of manufacturing building materials based on glass waste are based on technologies that involve sintering raw materials at high temperatures or processing them in autoclaves. Taking the high energy consumption and the cost of such technological operations into account, the most promising way to utilize broken glass at the expense of the building materials industry is to obtain a binder and concretes based on it, hardening at a temperature not exceeding 90 ° C [3, 4].

In this regard, studies aimed at developing compositions and studying the properties of autoclave-free porous concretes based on a glass-alkali binder are extremely relevant. An increase in the volume of production and the use of effective composite materials with a low average density, in particular, porous concretes, contributing to solving the problem of economical consumption of energy resources to maintain a given temperature regime of premises should also be taken into an account. This problem has got importance in connection with the adoption of a set of national programs aimed at reducing material consumption, lowering our economy's energy intensity, and conserving resources. The aim of the research is the possibility of obtaining porous concretes based on a glass-alkali binder, the study of their properties and manufacturing technology [5, 6, 7].

Research objectives are as follows:

- To determine the legality of porous concrete structural compounds formed on the basis of glass-alkali.
- To develop the compositions of porous concrete based on a glass-alkali binder, taking in to account the indicators of strength, thermal conductivity, vapor permeability, water and frost-resistance and chemical resistance.
- Select effective additives for porous concretes based on a glass-alkali binder, which will improve their physical and mechanical properties and increase their resistance to chemically aggressive media.
- Develop a technology for producing porous concrete based on a glass-alkali binder.

Compared to non-autoclaved porous concrete, porous lightweight concrete is characterized by relatively low binding, durability and easy deformation. Exceptional cohesion and workability distinguish porous lightweight concrete mixtures, and their usage significantly simplifies product molding and eliminates the burden of compacting the mixture during vibration laying. The strength of porous concrete can be 5-10 MPa, and the average density is 700-1400 kg / m^3. The strength and density of concrete depend on its structure. As a rule, fired porous materials (expanded clay, etc.) at the same density have a higher strength than a porous solution. Therefore, the maximum saturation of porous lightweight concrete with expanded clay (0.9 - 1.15 m^3 / m^3) contributes to an increase in its strength or a decrease in cement consumption [8]. Because the properties of porous concrete are significantly influenced by various technological factors, it is advised when selecting concrete compositions to take the design density 2-5% lower with the strength 10-20% higher than required on the project in order to obtain reliable results with possible fluctuations of these factors. Porous concrete was produced using the following technology. Pre-ground glass, expanded clay, and semi-aqueous calcium sulfate were crushed, weighted, and loaded into the mixer, mixed until a homogeneous mass was obtained. Then the filler is added to the components of the binder (expanded clay). The mixing of the dry mixture was carried out with a concentrated alkaline solution (The optimal amount of alkali was dissolved in a small amount of water). The necessary mobility can be achieved by adding an additional amount of water. In parallel, a suspension is prepared from a mixture of liquid sodium glass and aluminum powder. Then the finished suspension was added to the mixture and thoroughly mixed for 30 sec. The finished mixture was fed into molds and placed without the use of vibration. The molded products were kept in molds for one day under normal conditions. They are then hardened outside the mold under hot and humid conditions at 90^0C for 8 hours (respectively, the time of the temperature rise to the maximum, the holding time at the maximum temperature and the time for the temperature to drop from the maximum value to the normal value l). The composition of porous concrete is given in the table 1. The dependences of the change in the average density and ultimate strength in compression of porous concretes on the amount of gas-forming additive and the type of glass used are shown in Fig. 1 and Fig. 2.

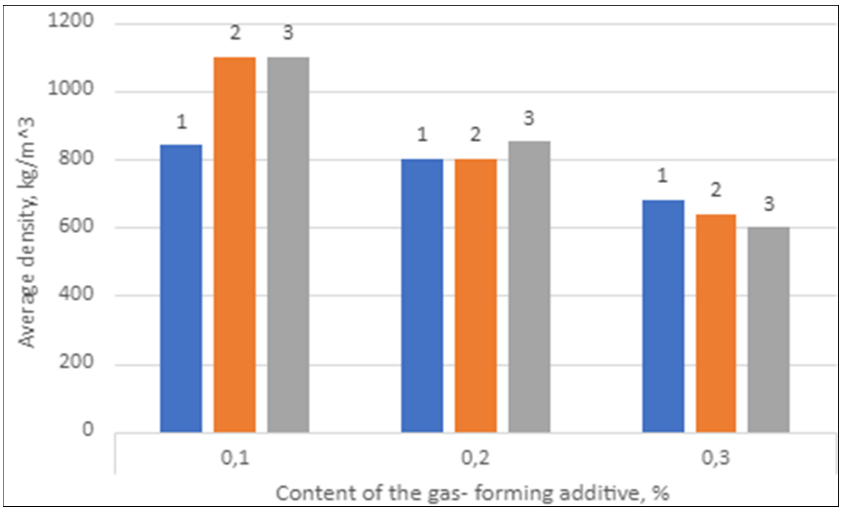

Fig 1: Dependence of change in the average density of porous concrete from the content of the gas-forming additive (2- container glass)

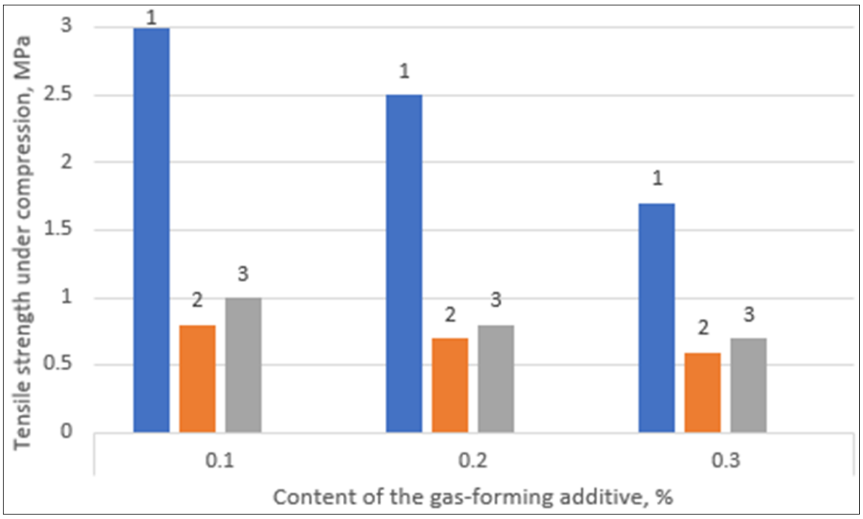

Fig 2: Dependence of change in tensile strength under compression of porous concrete from the content of the gas-forming additive (2- container glass)

Table 1: Porous concrete composition

Porous concrete components	Consumption of raw material, g
Finely ground cullet	200
Finely crushed expanded clay	50-60
Semi-water gypsum	15
Sodium hydroxide	28-30
Liquid soda glass	28-30
Aluminum powder	0.6

In addition, we investigated the change in the properties of porous concrete when using various fractions of coarse porous aggregate. The research results are shown in Fig. 3 and 4.

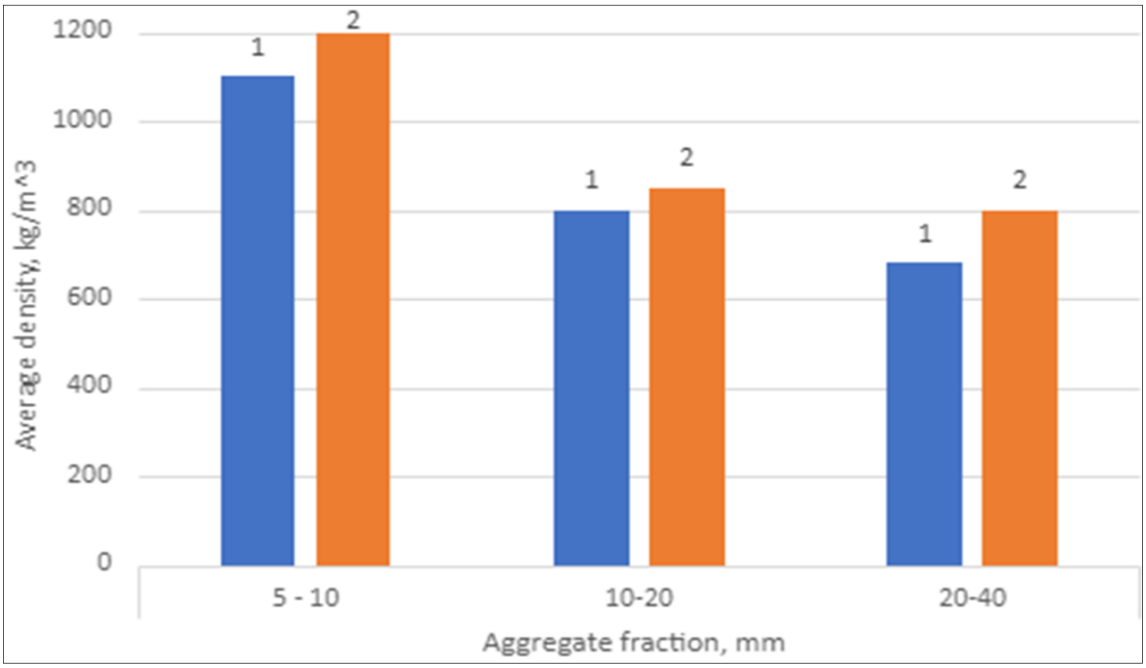

Fig 3: Dependence of change in the average density of porous concrete from fractional composition of aggregate (1- NaOH 5%, 2- NaOH 6%)

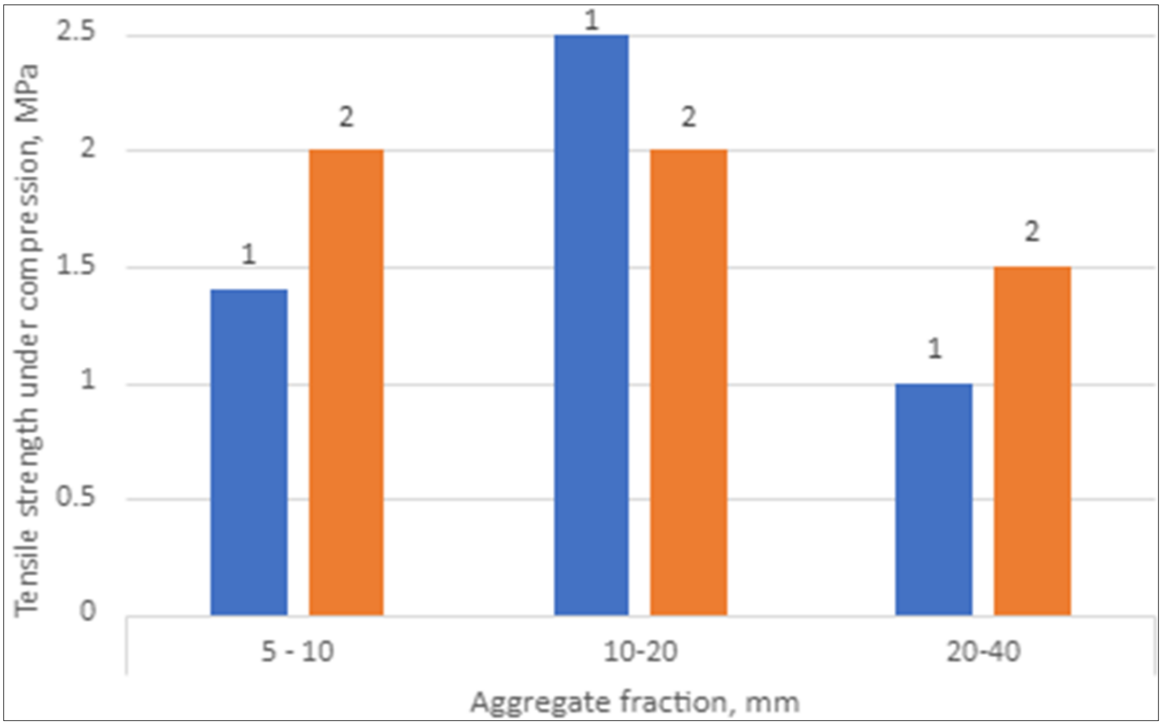

Fig 4: Dependence of change in tensile strength under compression of porous concrete from fractional composition of aggregate (1- NaOH 5%, 2- NaOH 6%)

The experimental results revealed that the bulk density of the coarse aggregate is the main factor affecting the average density of porous concrete, while its strength characteristics are not a key factor in increasing the strength of the composite. At the same time, the best combination of density - strength turned out to be inherent in the composition, the filler in which was expanded clay of 10-20 mm fraction. The physical and technical characteristics of small-piece wall blocks determined in laboratory conditions are given in table 2. Tests have shown the feasibility of using a glass-alkali binder for the manufacture of small-piece wall blocks from porous concrete that meet the requirements of regulatory documents.

Table 2

Indicator name	Meaning
Average density, kg / m^3	800
Compressive strength, MPa	2.3
Thermal conductivity, W / m 0C	0.16

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