Modifying non-autoclaved foamed concrete technology on the magnesia cement with crystal starter seed infusion

G F Averina¹, R A Zhivtcova¹, O I Kovaleva²

¹Department of Building Materials and Products, South Ural State University, 76, Lenin Avenue, Chelyabinsk 454080, Russia
²Department of Foreign Languages, South Ural State University, 76, Lenin Avenue, Chelyabinsk 454080, Russia

E-mail: averinagf93@gmail.com

Abstract. The article deals with the capability of non-autoclaved foamed concrete quality improvement by entrained mixture additives infusion into structure, which are the active centres of the basic phases magnesia stone crystal yielding. Two factor experiment of optimal concentration proportioning was conducted and finished by plotting graphic diagrams. The paper studies the basic mechanical characteristics of designed foamed concrete while conducting the experiment. We revealed a positive effect of crystallizing centres infusion on the speed of taking bearing power and resistance of modifying mixture. The paper studies the phase structure of hardened magnesia stone and determined the effect of the basic structure-forming minerals composition on the strength characteristics of foamed concrete on its foundation, along with the exploitation samples characteristics of optimized composition.

1. Introduction

Low-rise housing construction is widely spread on the territory of Chelyabinsk region. The fundamental material for house construction is cellular blocks, due to advanced characteristics and high thermal insulating properties. Growing demand makes us think over upgrading production technologies and usage of more energy efficient raw materials [1-5].

Cellular blocks are subdivided according to the production methods into autoclave and non-autoclaved ones. A wide range of different binding substances are used as raw materials. Due to special characteristics of the majority binders used, types of foamed concrete produced by the method of non-autoclaved hardening, have artificially high density pointers (indices), low strength and are subjected to extensive contraction in hardening process. Additional autoclaving of material helps us to avoid such defects appearance. This method is very energy demanding and expensive. Also it requires compliance with the increased requirements for work safety [6].

We can improve cellular blocks quality without autoclave treatment using binding materials with rapid-strength development in normal conditions. One of such binding material is the magnesia cement on the dolomite base. Such type of binding material application is economically feasible, because it does not require thermal treatment in the increased pressure condition [7-12].

By analogy with the known methods of concrete structure formation we can assume, that foamed concrete quality improvement can be achieved with crystallized starter seed infusion in the form of
magnesium hydroxide, which is the first phase of magnesium oxychloride cement and grouting fluid interaction [13-20].

2. Materials and research methods
We used magnesium oxychloride cement obtained by firing of low quality magnesium-containing earth material with additive agents. Foamed pearlite as light filling was used for reduction of binding quantity and increasing thermal-insulation characteristics. The quantity of pearlite took 20% from binding net weight.

We used magnesium oxide water solution as crystallizing starter seed for porous mixture. Starter seed mixture was input into foam while whipping the working mixture of foam-forming admixture.

We conducted two factor experiment for invention of magnesial foamed concrete composition. We chose solution density of grouting fluid (technological magnesium chloride) and concentration of magnesium oxide solution as factors.

3. Research part
Samples of obtained foamed concrete were assessed according to the density. They were tested for strength under compression for 3 and 28 days of hardening in dry conditions. The study was not conducted on the first day of hardening because of high sample humidity.

The experimental results were finished on electronic computing machine and summarized in graphic curves, given in figure 1-3.

![Figure 1](image1.png)  
**Figure 1.** Graphical relation of cellular concrete destiny on grouting fluid density and magnesium oxide laitance concentration (28th day).

![Figure 2](image2.png)  
**Figure 2.** Graphical relation of cellular concrete strength on grouting fluid density and magnesium oxide laitance concentration (3rd day).
Figure 3. Graphical relation of cellular concrete strength on grouting fluid density and magnesium oxide laitance concentration (28th day)

According to the results of relations we can come to the conclusion that obtained foamed concrete takes the marking density D 900. Tailored composition of obtained in the following technique foamed concrete can possess the strength class within B3 to B4. Optimal structure has density mark D 900, strength class B4, thermal conductivity index - 0.24 W/(m*K) and vapor transmission rate - 0.13 mg/(m*h*Pa).

We practically did not notice the growth of strength in samples from the third to twenty eighth day of hardening what is connected with basic stone structuring joining formation in the initial terms of material hardening.

For phase composition determination we studied samples of obtained foamed concrete within one day of air hardening.

The experimental results were finished on electronic computing machine and summarized in graphic curves given in figure 4-6.

Figure 4. Graphic relation of magnesium pentaoxyhydrochloride availability to grouting fluid density and magnesium oxide laitance.

According to the results of our study, a directly proportional dependence of the strength of the developed foam concrete on the density of the matrix is traced. The concentration of the crystalline seed solution increases the strength of the samples in the range from 10 to 20%. The density of the developed foam concrete compositions slightly increases with increasing density of the current agent and the concentration of the seed solution.

Also, according to the results of a preliminary study of foam properties, it was found that the introduction of a solution of magnesium oxide, which is a seed of crystallization of the structural phases of a magnesian stone, into a technical foam increases its stability for a long time (Table 1).
Table 1. Properties of technical foams.

| Type of foam concentrate | The concentration of magnesium oxide solution, % | Density, kg / m³ | Draft, mm | Cell’s wall thickness, μm |
|--------------------------|-----------------------------------------------|-----------------|-----------|-----------------------|
| Protein                  |                                               |                 |           |                       |
| 0                        | 76                                            | 2,2             | 16        |
| 10                       | 78                                            | 2               | 34,5      |
| 20                       | 80                                            | 2               | 40        |
| 30                       | 87                                            | 2               | 35        |
| 40                       | 90                                            | 1               | 34        |
| Saponified wood resin    |                                               |                 |           |                       |
| 0                        | 65                                            | 2,3             | 33        |
| 10                       | 68                                            | 2,2             | 46        |
| 20                       | 75                                            | 2,2             | 33        |
| 30                       | 83                                            | 2               | 30        |
| 40                       | 85                                            | 1               | 28        |
| Synthetic                |                                               |                 |           |                       |
| 0                        | 12                                            | 105             | 12        |
| 10                       | 18                                            | 82              | 18        |
| 20                       | 21                                            | 63              | 24        |
| 30                       | 27                                            | 46              | 21        |
| 40                       | 32                                            | 28              | 19        |
According to the obtained relations we can conclude that the tendency of magnesium pentaoxyhydrochloride availability raise in samples of produced foamed concrete is equivalent to tendency of given samples strength what coplies with the scientific facts. The compound of magnesium hydroxide and trioxyhydrochloride availability is not related to the strength dependencies.

4. Conclusions
Thus, conducting the research we discovered the composition modification effectiveness of non-autoclaved magnesian foamed concrete by magnesium hydroxide infusion in the form of aqueous solution. This compound is the primary phase of magnesia binder with any aqueous grouting fluid solution interaction. Its infusion into the binder dough promotes the activation of hydroxychloride phases in the earlier periods of hardening. The following additive infusion in the magnesian foamed concrete composition increases its strength characteristics by 30-35% depending on the grouting fluid density.

References
[1] Kuzmenkov M I and Bakhir E N 1997 Energy and resource saving in cement and other binding materials production I 83–7
[2] Istomin M Y 1998 Cand.Sc. (Technical science) Ulan-Ude (in Russian)
[3] De Silva P, Bucea L and Sirivivatnanon V 2009 Cem. And Con. Research 39 460–5
[4] Vaivad A Y, Gofman B E and Karlson K P 1958 Dolomite binding materials (Riga: Science) p 240
[5] Matkovich V and Rogich I 1976 VI In. Cem. Chem. Con. 2 94–100
[6] Russian Federation PB 03-576-03 Regulations for the Design and Safe Operation of Pressure Vessels
[7] Vaivad A 1971 Magnesian binders (Riga:Science) p 315
[8] Averina G F, Chernykh T N, Orlov A A and Kramar L Y 2017 Bull. of SUSU Series: Construction and architecture 3 40–7
[9] Prokofieva V V 1999 Building materials on magnesian raw materials 2 30–1
[10] Shelyagin V V 2006 Magnesia cement (Prospect of Science) p 206
[11] Kramar L Y 2007 Doct. Diss. (Technical science) (Chelyabinsk)
[12] Nosov A V Cand.Sc. (Technical science) Belgorod 2014 (in Russian)
[13] Matcovic B, Popovic S, Rogic V and Zunic J 1977 Amer. Ceram. Soc. 60 504–7
[14] Rogic V and Matkovic B 1972 Cement (Zagreb) 16 61–9
[15] Bergman G and Vyrodov I 1958 Jour. of App. Chem. 3 119–24
[16] Vyrodov I 1960 Jour. of App. Chem 33 2399–404
[17] Bergman G and Vyrodov I 1959 Jour. of App. Chem 32 504–9
[18] Matcovic B, Popovic S, Rogic V and Zunic J 1977 Amer. Ceram. Soc. 60 504–7
[19] Bilisuki H, Matcovic B, Mazuranic C and Zunic T 1984 Amer. Ceram. Soc 67 266–9
[20] Shelikhov N S 2008 Build. Mater. 10 32–3