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Experimental research of foam gypsum acoustic absorption and heat flow

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Among six more essential demands for the European building directive (The Construction Products Directive 89/106/EEC), which are advanced for building materials and its goods, is protection against noise, economy of energy and heat insulation. In 2004 in Latvia a building norm for building acoustic has been adopted (Latvian Building Normative LBN 016-03), which advances high demands for sound insulation in buildings. The majority of buildings in Latvia, built before 60-ies, do not correspond to these demands.
The Latvian building normative "Building acoustic", as one of sound absorbing materials offers porous material, which due to air friction in porous the sound energy transfers into heat.
Foam gypsum is produced using gyps cohesive substance, manufacture technology of which is environment friendly and energy efficient. Foam gypsum like well known other gypsum products, gypsum paperboard as fire resistance material can be used. Nowadays using the technology of dry mineralization (Skujans et al, 2007) it is possible to obtain foam gypsum with different apparent density and pore dimensions. Such materials muffle sound in certain range of frequency; therefore it is possible to use them for manufacturing multilayer foam gypsum products for practical application. Besides foam gypsum posses good heat insulation properties too, which is essential for the development of environment protection problems.
The acoustic properties of this porous material with changeable apparent density, foam gypsum is not enough investigated. It is possible to use foam gypsum in walls as sound and heat insulating material, as well as for interior decoration of premises.

1. Materials and Methods

1.1. Production technology of acoustic foam gypsum samples

Samples for acoustic investigation of 12.5 mm thick moisture resistant gypsum paperboard, produced by the company "Knauf", covered by a layer of foam gypsum of certain thickness have been manufactured. The gypsum paperboard beneath the layer of

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foam gypsum is necessary in order to ensure the bending strength of the foam gypsum. The foam gypsum, using the method of dry mineralization, has been produced (Skujans et al, 2007).

1.2. The methodology of foam gypsum sound absorption investigation

The sound absorption measurements have been carried out using the company's "Sinus" an impedance tube produced by industry (Fig.1). By the tube it is possible to measure the sound absorption coefficient in the range of frequencies from 250 Hz up to 4000 Hz, when the sound reflects from the sample.

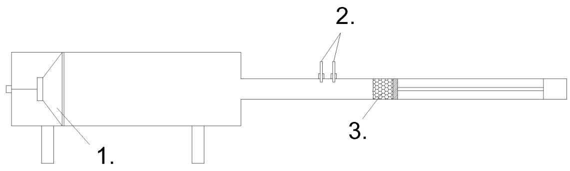

Fig.1. Device produced by the company "Sinus" for measuring the sound absorption: 1-sound source, 2-measuring microphones, 3-measurable sample.

The impedance tube has two different diameters Ø100 mm and Ø40 mm. In the tube part of Ø100 mm the sound source is placed, but in the part of Ø40 mm, two measure-microphones and the sample of Ø40 mm, to be measured, is located. The sound muffle coefficient (α) is determined by formula:

$$\alpha = \frac{I_{abs}}{I_{fal}} \qquad (1)$$

where I_{abs} – intensity of absorbed sound;
I_{fal} – intensity of the sound falling on the sample.
The mean value of the absorption coefficient for all range of frequencies is determined according the standard of the European Union (EN ISO 11654:1997).

1.3. The investigation methodology of foam gypsum pores

The investigation of foam gypsum pores by the use of digital microscope VNX-100 has been carried out. Before the investigation of pores under the microscope, the samples have been ground with following cleaning of the surfaces from the dust.

The measurements of pores for each of samples were measured in five places with 50 times magnification. The disposition of spots of measurements made a cross on the sample surface. In each of 5 positions the picture, seen in the object-glass, in 1x1 mm squares has been divided. From this three regions were chosen in which pores at 15 reiterations were measured. The pores making the porous structure of samples do not have ideally round shape. Therefore the area of pores per 1 mm^2 instead of its diameter has been determined. Large amount of pores are linked with adjacent ones. The cross-sectional area of these joint pores is distinctive for different samples and depends on its volume-mass, amount of active surface stuff, added during the production process of the sample, as well as other reasons related with the technology used at production of foam gypsum.

2. Experimental results

Varying at the process of manufacturing with the ratio of gypsum and water, as well as volume of surface active stuff (SAS), samples of different apparent density *have* been obtained. Measuring the value of sound absorption coefficient at certain thickness of sound absorbing layers, the increase of this value in the high frequency range in Fig.2 is seen. As it follows from Fig.2 the sound absorption coefficient depends on the apparent density of an acoustic foam gypsum sample. In Fig.3 the mean value of the sound absorption coefficient as the function of foam gypsum sample apparent density at the thickness of 82 mm is shown.

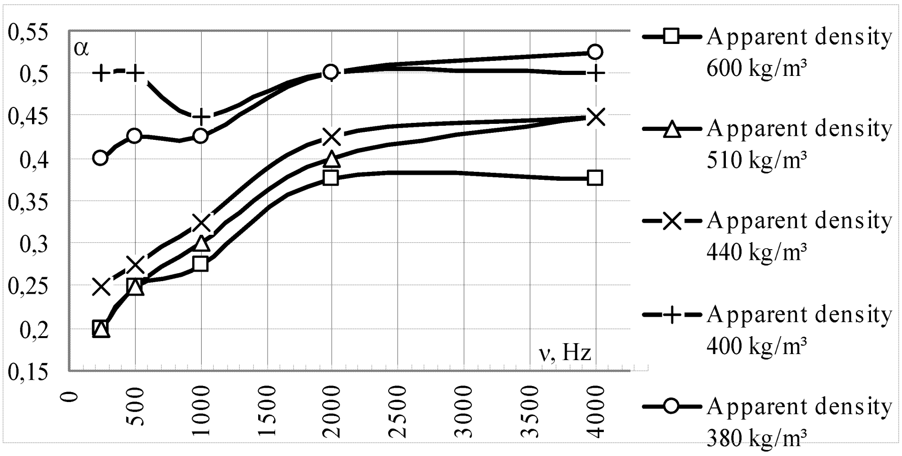

Fig.2. The value of sound absorption coefficient depending on the frequency of samples of different apparent densityat the thickness of 82 mm.

The obtained result coincides with the dependence of foam gypsum heat transfer coefficient on apparent density investigation (Skujans, 1987) Fig.4, because of acoustic foam gypsum samples of insignificant volume-mass apparent density. About this also testifies investigation in sound absorption of foam gypsum at frequencies 1000 Hz, $\alpha = 0.89$ at $\rho = 220$ kg/m³ (Skujans,1987), and $\alpha = 0.8$ at $\rho = 120$ kg/m³ (Konig, 1993).

In Fig.6 the foam gypsum sample with apparent density 600 kg/m^3 pores structure at 50 times magnification is shown. The mean pores area per 1 mm^2 depending on foam gypsum apparent density is shown in Fig.7, but in Fig.8, the mean value of the absorption coefficient depending on pores area. From these figures it is seen that the mean absorption coefficient increases, if pores area increases. It corresponds with the Fig.3 obtained results.

The experimental investigation will be continued, because by varying with VAV and water gypsum ratio, we can change all gypsum parameters. It makes us possible to obtain the necessary value of the sound absorption coefficient in dependence on the necessary specified sound frequency range.

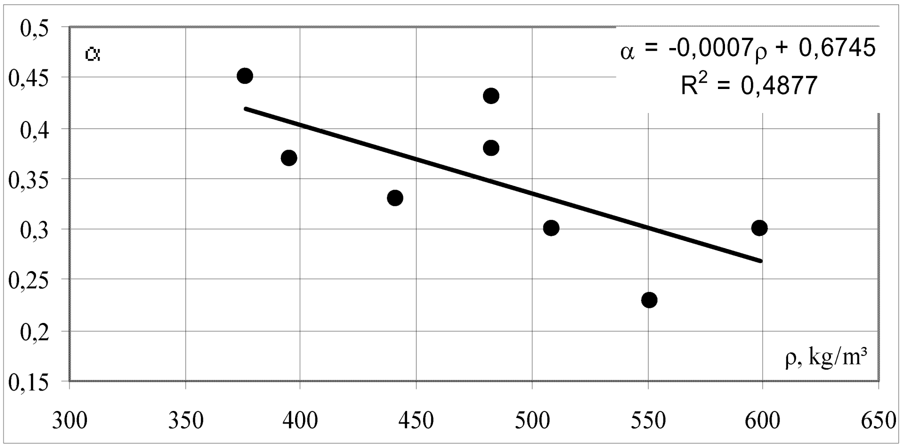

Fig.3. The mean value of foam gypsum sound absorption coefficient depending on its apparent density at the thickness of the sample 82 mm.

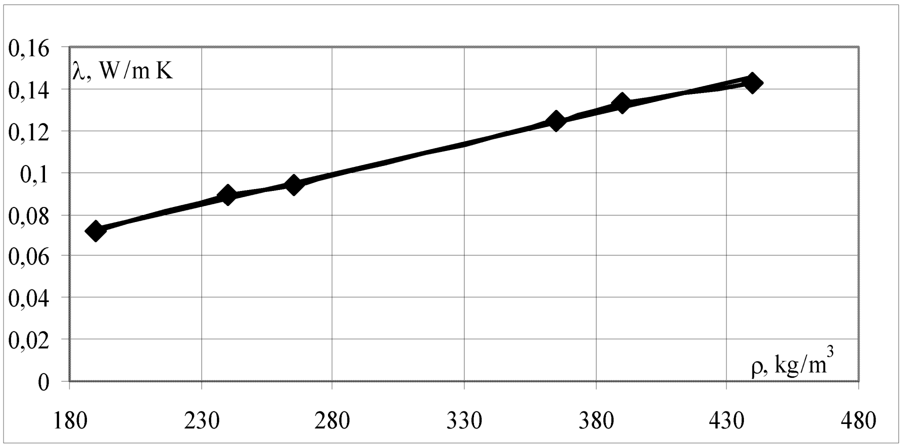

Fig.4. The value of foam gypsum heat transfer coefficient depending on foam gypsum apparent density.

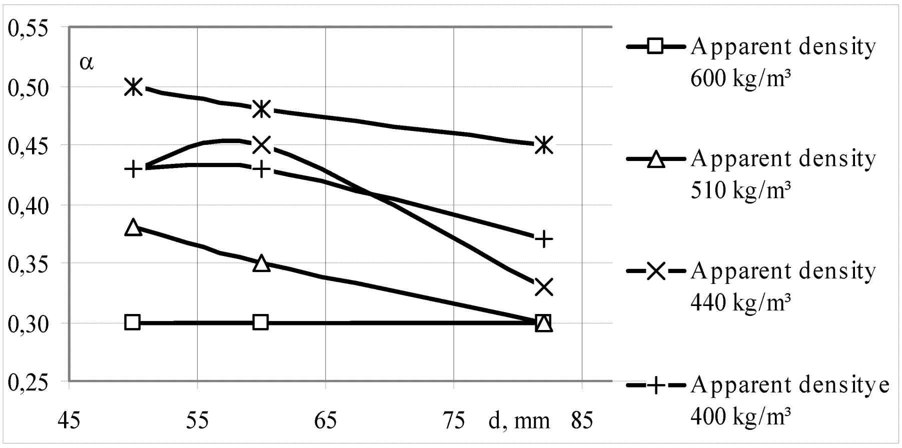

Fig.5. The dependence of the sound absorption coefficient mean value, of acoustic foam gypsum sample, on the thickness of the sample.

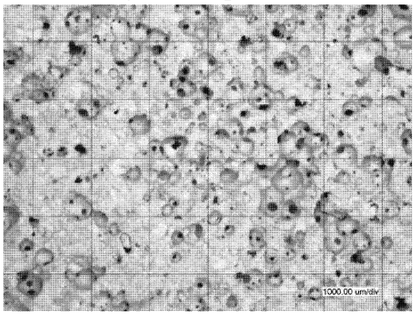

Fig.6. The foam gypsum of apparent density 600 kg/m^3 pores structure at 50 times magnification.

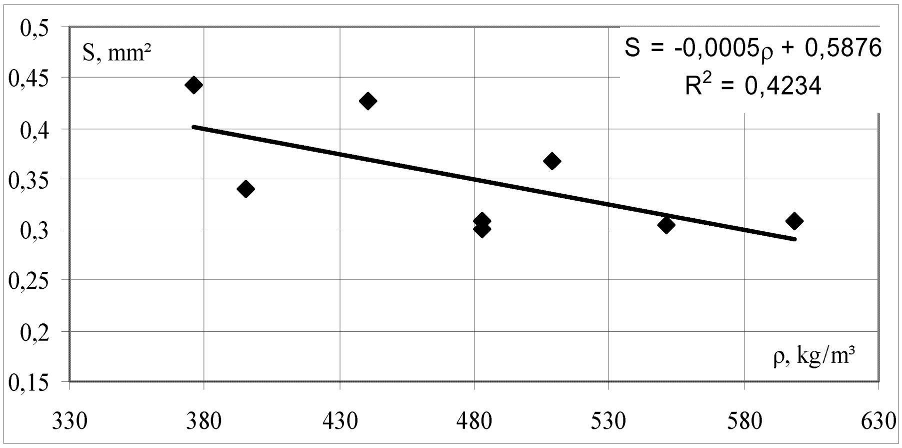

Fig.7. The acoustic foam gypsum pores area depending on apparent density ρ.

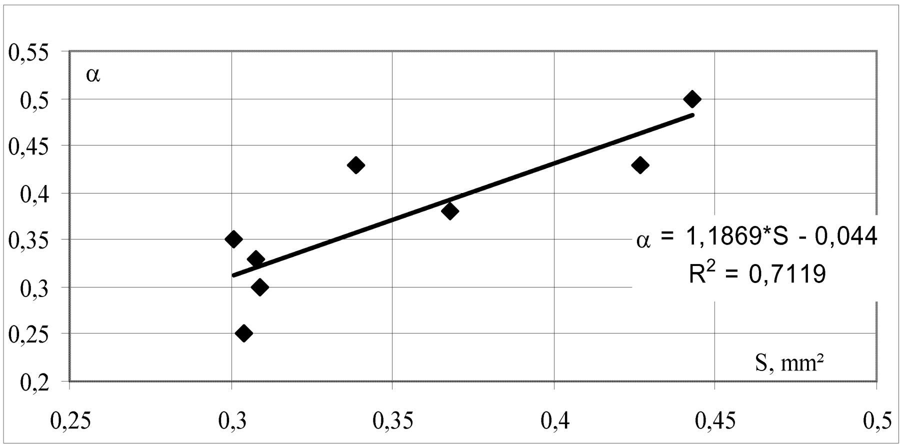

Fig.8. The value of acoustic foam gypsum samples sound absorption coefficient depending on the pores area per 1 mm^2.

3. Discussion

As a result of the investigation, the question remains discussable: what the foam gypsum structure would simultaneously insure the optimum of sound absorption and heat insulation? This issue is a question of material production technology.

Conclusion

1. In the investigated volume-mass (ρ) range of the acoustic foam gypsum sample, the absorption coefficient increases, when the apparent density of foam gypsum decreases. At small apparent density the acoustic foam gypsum samples can also serve as additional heat insulation material, which corresponds with the information, obtained in the literature at $\rho = 200 kg/m^3$; $\lambda = 0.08$ W/m·K.
2. Additional investigation of the influence of foam gypsum pores structure on sound absorption and heat insulation properties is necessary.

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