UDC 691

THE INFLUENCE OF THE MICROSTRUCTURE ON THE ACOUSTIC PROPERTIES OF BUILDING MATERIALS

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The analysis of the structure of single-layer and two-layer samples, as well as a physical explanation of the propagation of sound waves in building materials of various structures. A comparative analysis of the soundproofing and sound absorbing properties of the applied samples is given. Determining the sound transmission of building materials and their combinations.

Introduction. Acoustics (from the Greek. Acustikos - listening) is the science of sound. Building acoustics solves the problem of ensuring a normal sound mode in rooms for various purposes. The main task of modern building acoustics is to reduce the level of noise pollution in rooms. Noises are called sounds caused by various reasons, but not carrying useful information. Noise has a negative effect on the mental and physical health of a person. Reducing the level of noise pollution of the environment in which a person is located is an important biomedical and social task [1]. Noise arising in the room can be divided into external and internal. The main source of external noise in residential development are vehicles. Noise is usually characterized from a physical and physiological point of view. The physical characteristic of noise includes the magnitude of sound pressure and the distribution of this pressure over frequencies — the noise spectrum. The physiological characteristic of noise is determined by its effect on the human body; medium- and especially high-frequency noise is the most harmful [2].

One of the key parameters that affects labor productivity, creativity and health is acoustic comfort. Acoustic factors such as sound insulation and sound absorption play an important role in the design of work and living spaces. Electronics, heating, ventilation and air conditioning, mechanical appliances and other noise-producing equipment in the office, as well as the people themselves, are the main sources of noise in the room. Leisure places such as restaurants, cafes, cinemas and theaters require a separate approach to acoustic design.

Task formulation. In the research, we consider the main properties of acoustic materials in order to obtain information about the principle of propagation of sound waves in them, as well as their practical application, and we study the macro and micro structures of each sample using an Axiovert-10 microscope. The basic elements of the designed and manufactured training acoustic camera, which is further used to study the acoustic characteristics of building materials are described. As building materials, samples from drywall, wood concrete, foam plastic, foam rubber, ecotherm, armstrong were studied both individually and in combination.

Methods of research. The measurements were carried out in one-third octave bands with geometric mean frequencies of 100-8000 Hz, in accordance with TKP 45-2.04-154-2009 [3]. Prepared samples of the studied materials with dimensions of 40x45 with different thicknesses are placed in an acoustic chamber. Measurement of sound pressure level in the sound camera and sound waves, followed by the output of the output data.

Working process. The study used a training acoustic camera [4] and samples of the studied materials. First, sound transmission was measured in an empty chamber, then with the test materials being placed in the chamber, and sound transmission, sound absorption, and sound reflection coefficients were calculated. Sound absorption depends on the frequency and in practice is expressed by the sound absorption coefficient:

$$\alpha_1 = \frac{E_1}{E_2} \tag{1}$$

where α_1 - sound absorption coefficient;

E_1 - energy of the absorbed sound wave;

E_2 - energy of the incident sound wave.

Similarly, the reflection coefficient can be determined by the formula:

$$\alpha_2 = \frac{E_3}{E_2} \tag{2}$$

where α_2 - sound reflection coefficient;

E_3 - energy of the reflected sound wave.

And the sound transmission coefficient is then defined as:

$$\alpha_3 = \frac{E_4}{E_2} \quad (3)$$

E_4 - energy of the transmitted sound wave.

Also considering that:

$$\alpha_1 + \alpha_2 + \alpha_3 = 1 \quad (4)$$

We have studied single-layer samples: drywall, arbolite [5], armstrong, as well as combined two-layer samples: drywall and ecotherm, drywall and plastic foam.

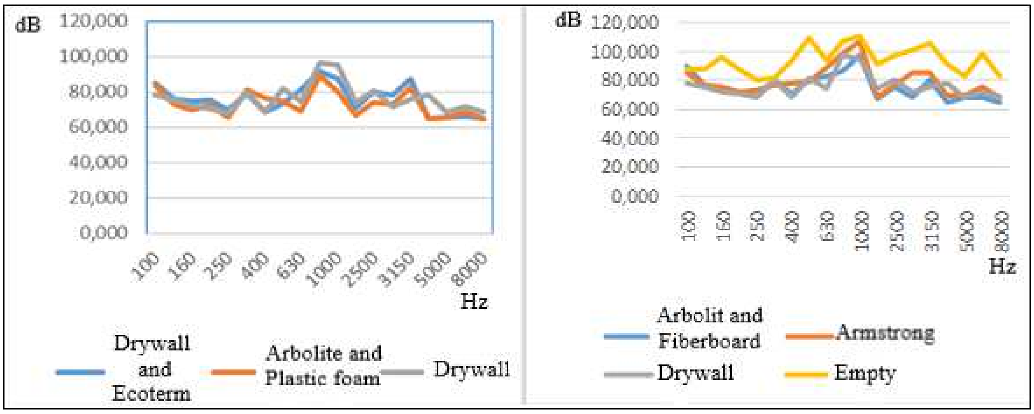


Figure 1. – Comparison chart materials for sound transmission

An analysis of the above graphs showed a decrease in noise level by an average of 18.34 dB for wood concrete with fiberboard, by 14.61 dB for armstrong, by 17.63 dB for drywall, by 18.14 for drywall and ecotherm, by 20.38 dB for drywall and plastic foam in comparison with the initial data.

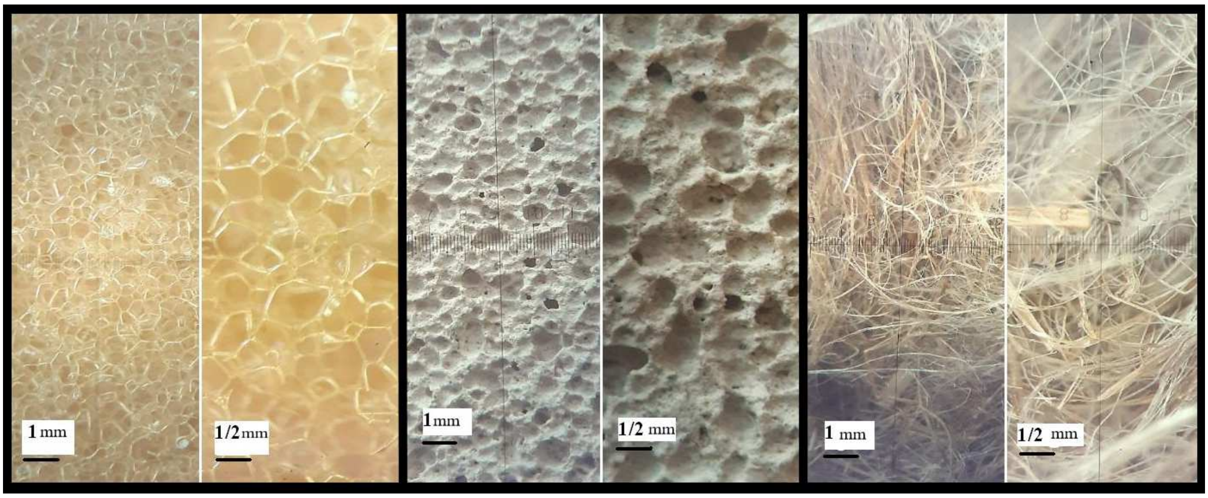
Table 1. - The results of measurements of the acoustic properties of materials.

acoustic odds / material	Armstrong	Arbolite	Drywall	Drywall + ecotherm	Drywall + plastic foam
Sound Absorption Average, %	12.0	15.0	15.4	15.9	19.1
Sound reflection Avereage,%	3.990	4.202	3.763	3.1	2.746
The average value of sound transmission,%	84.6	80.8	81.5	81	78.7

The ability of materials to absorb sounds is mainly due to their porous structure and the presence of a large number of communicating open pores from the side of the sound. The maximum pore diameter should not exceed 2 mm, and the total porosity should be at least 75% [6]. This is due to the fact that when a sound wave passes through the thickness of the material, it brings the air enclosed in its pores into oscillatory motion. In this case, small pores create greater resistance to air flow than large ones. The movement of air in them is inhibited, and as a result of friction, part of the mechanical energy is converted into heat. The higher the open porosity of the insulating surface, the higher the sound absorption.

Acoustic materials are similar in structure to heat-insulating materials. Both materials require high porosity (Fig. 2). However, due to the fact that the nature of the influence of heat and sound flow is different, the nature of the optimal structure is different for them. Hence, the most effective heat-insulating materials are those that have closed finely porous structure that excludes air convection. Acoustic, in particular, sound-absorbing materials should have an open porous structure capable of absorbing sound energy [6].

Sound-absorbing materials can have a fibrous, granular or cellular structure and have varying degrees of stiffness (soft, semi-rigid, hard). The sound-absorbing properties of materials are also affected by their elasticity. In products with a flexible deformable framework, there are additional losses of sound energy due to the active resistance of the material to forced vibrations under the influence of incident sound waves [7].



(left side- Foam rubber, middle side- Gas silicate block, right side- Ecotherm)

Figure 2. – Images of the structure of materials

Nowadays, the most versatile soundproofing materials are materials based on natural raw materials, for example, products based on stone (basalt) wool. Due to their specific structure, they have very good soundproofing abilities. When sound waves fall on the material, its finest chaotically directed fibers transform the energy of sound vibrations into thermal energy by friction with each other. Figure 2 shows the microstructure of the ecotherm, which is made of flax and has both excellent thermal insulation and soundproofing characteristics.

Conclusion. According to the results of the experiments, a comparative analysis of the sound-insulating and sound-absorbing abilities of the partitions showed that the combined two-layer sample (drywall and plastic foam) has the best acoustic properties. Thus, this combination can be used for wall decoration, where good acoustics such as a movie theater and the like are very important.

The surfaces of acoustic materials examined under a microscope demonstrate the potential for sound absorption and sound insulation. Porous and fibrous materials are more likely to absorb sound than closed cell structures. When materials with closed cell structures are more suitable for sound insulation purposes.

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