

Technical and economic comparison of soundproof wall panels

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Abstract. The world of sounds accompanies a person from the day of his birth and throughout his life. With the achievement of a high level of civilization, the level of acoustic pollution in the world has also grown. Noise is a set of undesirable sounds that are not important and do not carry information. Noise pollution affects human health and manifests itself in hearing impairment, leads to chronic diseases, and also leads to fatigue. In connection with the increased demand for acoustic comfort in the construction market, many soundproof structures and materials have appeared. The paper compares the main soundproof wall panels and chooses the most optimal variant. The main properties and characteristics of the panels are presented in tabular form.

1 Introduction

Nowadays, due to the growth of cities, industry, and transport, and therefore due to the growth of noise in the world, the problem of creating acoustic comfort and sound insulation during the construction and operation of residential, public, and industrial buildings is of high priority [1-3]. This is due to the fact that the noise adversely affects the body and the emotional background of the person, reduces his efficiency, and interferes with normal sleep and proper rest. With the modern rhythm of life, it is nearly impossible to avoid noise, as it follows us everywhere: on the streets of cities - due to the appearance of a large number of vehicles: buses, trucks and cars, rail, air and water vehicles; inside buildings - due to the operation of ventilation, air conditioning, cold supply, and air heating systems.

Sound insulation of the premises today is a necessity of the time, because violation of the rest mode and emotional background can lead to much more serious consequences than just constant fatigue. The hearing organs and the cardiovascular system, which is very sensitive to any stress, start to suffer first [4-6]. According to studies, the impact of strong noise causes the following mental disorders: disorder of the nervous system and internal secretion system, changes in the self-preservation instinct, inability to self-control, unwillingness to work, and violation of a balanced state.

The degree of manifestation of unwanted sound effects on the human body depends on the parameters of noise, the duration of the effect of noise, and individual sensitivity.

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Investigation of the impact of noise on residents of different gender and age showed that women and persons of older age groups are most sensitive to it.

Therefore, it is very important that when we come home, each of us could stay a little in silence and restore strength.

To create a favorable acoustic environment, various architectural planning and construction (constructive) methods are used. Manufacturers of sound insulation materials offer many options, and it is very difficult to choose the most optimal one [7,8]. In this paper, several types of soundproof wall panels are considered.

An analysis of the literature on this topic has shown that the problem of protection against increased noise is a serious problem that is being addressed worldwide [4, 7, 9–15]. This problem applies not only to industrial premises, where an increased level of noise is due to the intricacies of the technological process [15,16,17], but also to ordinary houses, apartments, and offices. Studies of the features of sound insulation of the rooms were done by [1,15,18].

At present, in the area of rationing acoustic and sound insulation characteristics of building structures in Russia, there are construction set of rules SP 51.13330.2011 “Noise protection” [19] and SP 23-103-2003 “Designing sound insulation for enclosing structures of residential and public buildings” [20]. Among all the proposed literature, we can conclude that there are many soundproof materials and structures. However, it should be noted that there are few papers containing information on soundproof wall panels [15,21,22], therefore this topic is relevant.

2 Materials and Methods

The purpose of this work is the analysis and comparison of soundproof panels presented on the construction market, according to their physical, mechanical, and acoustic characteristics, according to the degree of fire risk, as well as other distinctive features.

To achieve this goal, it is necessary to perform the following tasks:

- Conduct a brief analysis of noise in the building and its classification;
- Consider the advantages of sound panels in general;
- Consider the main types of sound wall panels in the construction market and present a comparative analysis in tabular form;
- On the basis of the obtained results, make recommendations on the choice of the most optimal variant of the sound insulation panel.

As the noise impact, unwanted sounds arising inside the building or coming from external sources are understood [23,24].

According to the place of occurrence, the noise is divided into:

Airborne - the noise that propagates through the air (baby crying, dog barking). Partitions, walls to some extent damp the airborne noise. However, ventilation, sockets, and various openings can be an excellent pass for noise, like the walls themselves, through which vibrations pass.

Impact - the noise that occurs due to the direct impact on the structural elements of the building (sound of heels, repair work). In this case, oscillations occur, which are transmitted along walls, ceilings, and floors over long distances.

Structural - the noise that occurs when utility systems vibrate in the building (noise in pipes, noise from ventilation systems).

The noise propagation in the building is shown in Figure 1.

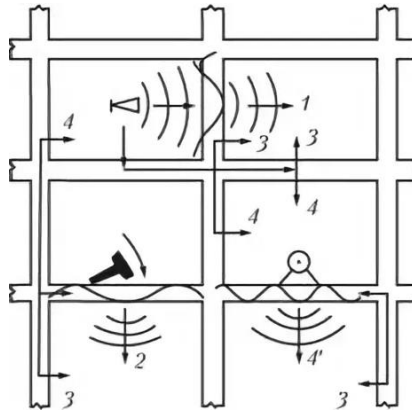


Fig. 1. The noise propagation in the building, where: 1 - the propagation of airborne noise; 2 - the propagation of impact noise (direct noise transmission paths); 3, 4 – indirect (bypass) ways; 4' - the propagation of structural noise emitted by structures associated with vibrating mechanisms and elements of engineering equipment.

By the mode of the propagation, noise can be penetrating, constant, non-constant, tonal, pulsed. To protect the premises from penetrating noise, there are several ways, one of which is sound insulation of the exterior and interior walls of a building [15].

3 Results

In recent years, the production of sound insulation has taken a big step forward; modern technologies make it possible to create quite thin panels that are not inferior in their properties to framed multi-layer structures.

Soundproof panels are a versatile combined soundproofing system that is a slab material used to protect residential and public buildings from noise [15,25]. Such panels have many advantages compared with other materials designed to absorb noise:

Durability. If all the rules of installation and operation are observed, the panels can last more than 20 years.

Versatility. The panels can be installed in any room (apartment, private house, industrial enterprise), including where specific conditions have been created, for example, at high humidity.

Thermal insulation properties. Along with protection from extraneous sounds, the panels help to reduce heat loss, thereby reducing the cost of heating the building [26].

Environmental friendliness. Materials used in the manufacture of soundproof wall panels are certified, which indicates their hypoallergenic qualities.

Let us consider some types of soundproof panels:

1) ZIPS-Module - a solution to the problem of additional sound insulation of existing walls and ceilings. With the help of such panels, most of the tasks of increasing sound insulation in residential and public buildings are solved. The total thickness of the ZIPS-Module soundproofing system together with the finishing layer of gypsum board is 83 mm (Fig. 2) [11].

2) The PhoneStar-Triplex panel - a soundproof panel consisting of environmentally friendly components: a cellulose cage and mineral filler (Fig. 3). With its small thickness, PhoneStar effectively deals with both airborne and impact noise. The panels are designed for sound insulation of walls, partitions, floors, and ceilings of civil and industrial buildings.



Fig. 2. ZIPS-Module.



Fig. 3. PhoneStar-Triplex.

The EcoZvukoIzol panel is a Russian soundproof construction. The panels provide a multiple decrease in impact and sound energy of the wave over the entire frequency range (Fig. 4). This result is achieved due to the massiveness (multilayers). The panel is a solid seven-layer cardboard profile filled with heat treated mineral quartz filler of specially selected granulation [15, 29].



Fig. 4. EcoZvukoIzol.

The main parameters of the presented soundproof panels are described in Table 1. For a comparative analysis of the effectiveness of acoustic materials, it is advisable to introduce a parameter of effective density that takes into account the mass of the sound insulating structure occupied by a volume of 1 m³ [30-33]. Other things being equal, the rule is observed: the higher the effective density of the material, the higher its sound insulation capacity.

Table 1. Acoustic materials.

| № | Firm | Material | Panel size, mm ² | Own thickness, mm | Thickness (in construction) mm | Loss of living space with sound insulation, m | Effective density, kg/m ³ |
|---|---------------------------------|-------------------|-----------------------------|-------------------|--------------------------------|---|--------------------------------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1 | Acoustic Group Company (Russia) | ZIPS-Module | 1200x600 | 70 | 83 | 0,083 | 694,4 |
| 2 | PhoneStar (Germany) | PhoneStar-Triplex | 1195x795 | 12 | 16,8 | 0,0168 | 1473,6 |
| 3 | SoundGuard (Russia) | EcoZvukoIzol | 1200x800 | 13 | 17 | 0,017 | 1403,5 |

The parameter introduced above makes it possible to evaluate in the first approximation the efficiency of a material or structure not only from a technical point of view but also from an economic one. Among a number of different properties of soundproof materials, sound insulating characteristics are decisive [15]. The normalized parameter for sound insulation of internal enclosing structures in residential and public buildings, as well as auxiliary buildings of manufacturing enterprises, is the index of airborne noise insulation by enclosing structures R_w . The index is determined by comparing the frequency response of airborne noise insulation with a special estimated curve, measured in dB [19]. For comparison of the soundproof materials presented in column No. 3 of Table 2, airborne noise insulation indexes R_w for the partition of a panel building are proposed. These data were obtained using the graph-analytical method for calculating walls with a flexible slab [15,29]. For comparison, the standard values of the airborne noise insulation index are given in accordance with the SP "Design of sound insulation of enclosing structures of residential and public buildings" [20].

When choosing a material, its safety is equally important. And, of course, the most important role is played by the fire safety of the material [34] (Table 2). The fire hazard class of construction materials is determined in accordance with the federal law on fire safety requirements for materials and is characterized by the following properties [15,34-36]:

- combustibility (slightly combustible (G1), moderately combustible (G2), normally combustible (G3), highly combustible (G4));
- flammability (inflammable (V1), moderately flammable (V2), highly flammable (V3));
- smoke-generating ability (with a small smoke-generating ability (D1), with a moderate smoke-generating ability (D2), with a high smoke-generating ability (D3));
- toxicity of combustion products (low hazard (T1), moderately hazardous (T2), highly hazardous (T3), extremely hazardous (T4));
- ability of flame propagation over the surface (non-propagating (RP1), weakly propagating (RP2), moderately propagating (RP3), strongly propagating (RP4)).

Table 2. Properties of soundproof panels.

| No | Material | Airborne noise insulation index calculated for partition R_w , dB | Normative index of airborne noise insulation R_w , dB | Fire hazard of soundproof panel |
|----|-------------------|---|---|---------------------------------|
| 1 | 2 | 3 | 4 | 5 |
| 1 | ZIPS-Module | 59 | 54 | G1/V1/D1/T1/RP1/KM1 |
| 2 | PhoneStar-Triplex | 56 | 54 | G4/V2/D2/T1/RP2/KM3 |
| 3 | EcoZvukolzol | 57 | 54 | G2/V2/D2/T1/RP1/KM1 |

Table 3 presents data of manufacturers and dealers of the North-Western District on the cost of materials and cost of installation [31]. In order to make final conclusions on the choice of the most economical and high-quality soundproofing material, we calculate the reduction in useful area ΔS , as well as the material costs for the materials and installation itself (Table 4).

Suppose you need to soundproof all the walls in a room of 25 m². Each wall in this room has a length of 5 m and a height of 3 m, respectively, the perimeter of the room is 20 m, and the total area of all walls is 60 m². To find the value of the reduction of the useful area ΔS , it is necessary to multiply the obtained perimeter by the value of column No. 7 of the Table 1.

Table 3. Cost of materials and works.

| № | Material | Cost of material, rub/m ² | Cost of installation on a wall, rub/m ² | Cost of installation on a lathing, rub/m ² | Total cost of installation on a wall, rub./m ² | Total cost of installation on a lathing, rub/m ² |
|---|-------------------|--------------------------------------|--|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | ZIPS-Module | 1260 | - | 740 | - | 2000 |
| 2 | PhoneStar-Triplex | 1280 | 500 | 810 | 1780 | 2090 |
| 3 | EcoZvukoIzol | 890 | 500 | 810 | 1390 | 1700 |

To determine the material costs, it is necessary to multiply the total area of the walls by the value of column No. 6 of the Table 3 (obtained values will not take into account the residue of window and door openings).

Table 4. The cost of sound insulation of a wall.

| № | Material | Reduction of useful area ΔS , m ² | Cost of sound insulation when installed on a wall, rub. | Cost of sound insulation when installed on a lathing, rub. |
|---|-------------------|--|---|--|
| 1 | 2 | 3 | 4 | 5 |
| 1 | ZIPS-Module | 1,66 | - | 120000 |
| 2 | PhoneStar-Triplex | 0,336 | 106800 | 125400 |
| 3 | EcoZvukoIzol | 0,340 | 83400 | 102000 |

Analysis of these tables shows that the soundproofing system ZIPS-Module has an average cost, the highest sound insulation parameters, but it has the greatest thickness (83 mm), which significantly affects the reduction of the useful area of the room. The PhoneStar Triplex panel has the smallest thickness of 12 mm and the highest cost, as well as fire hazard KM3 (medium fire risk level). EcoZvukoIzol is the cheapest system with all installation options; it has average sound insulation values and a low level of fire hazard: KM1.

4 Conclusions

As a result of the analysis, we can make the following conclusions:

1. Protection against elevated noise levels is one of the most important tasks in the design and construction of civil and industrial buildings and structures. The solution to this problem is necessary for the creation of an acoustically comfortable environment in residential premises and at workplaces.
2. The most effective method of reducing airborne noise is the use of soundproof panels.
3. A comparison of such soundproof panels as ZIPS-Module, PhoneStar-Triplex, EkoZvukoIzol was made.
4. When comparing, the EkoZvukoIzol panel of the Russian company SoundGuard turned out to be the most advantageous sound insulation option, as it showed good acoustic characteristics and is an environmentally friendly and safe material, scarcely reduces the useful area of the room and requires relatively small material costs.

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