

Investigation of Noise - Vibration-Absorbing Polymer Composites Used in Construction

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Abstract. In order to ensure normal ambient conditions, people should be provided with a comfortable environment in residential and non-residential facilities: lighting, temperature, humidity, noise level, etc. The current issue in residential soundproofing is high noise transmission between flats located on the same floor. As a rule, this issue is addressed by increasing the thickness of soundproofing material at the expense of living space. Highly porous lightweight materials are used: cork, polyethylene foam, polyurethane foam, TermoZvukoIzol. The practical application of these materials revealed an insignificant acoustic effect as they are used to insulate impact noise. With the state-of-art vibroacoustic equipment and approved methods, the multimethod research was performed to study foam rubber as a material that increases acoustic comfort. It was found that acoustic comfort could be achieved by using the Russian vibration/sound absorbing polymer composite materials without sacrificing significant space.

1. Introduction

In order to ensure normal ambient conditions, people should be provided with a comfortable environment in residential and non-residential facilities: lighting, temperature, humidity, noise level, etc. [1].

Given the existing high noise pollution, people face the acute problem of protecting themselves from noise. Among the main noise sources are process and engineering equipment; road and railway traffic; marine traffic in waterways; air traffic in approach zones; manufacturing, municipal and energy facilities and their individual plants; vehicles on driveways and parkways; ventilation and air conditioning systems; central heating stations; shop utility areas; construction sites, etc. Insulators, screens, sound absorbing construction materials are most often used for indoor noise reduction [2-5].

When buying a home, one has to face the nonvisual factors that can significantly affect living comfort in the future. One of these factors is soundproofing. There are two categories of floor/ceiling noise: impact noise and airborne noise. These categories got their name due to the way of acoustic impact on a slab. Impact noise occurs from a direct physical impact of objects on a floor/ceiling slab. The sources of airborne noise are various sounds that are transmitted through the air, hit the slab, make it vibrate and retransmit the sound to a neighboring apartment [6].

The current issue in residential soundproofing is high noise transmission between flats located on the same floor. As a rule, this issue is addressed by increasing the thickness of soundproofing material at the expense of living space. For extra soundproofing, lightweight frame panels are most often used.



They are covered with plasterboards or fiber-reinforced gypsum boards, and have sound absorbing material inside. Among the modern materials that provide additional sound insulation for walls and slabs are readymade ZIPS tongue-and-groove sandwich panels with a thickness up to 133 mm. They are a combination of dense (fiber-reinforced gypsum boards) and light (mineral wool and/or staple glass fiber) layers [7].

The fight for better acoustic comfort along with the desire to preserve initial space drives a search for new soundproofing materials and structures with low thickness, which can provide a hard front surface to be painted or wallpapered.

Highly porous lightweight materials are used: cork, polyethylene foam, polyurethane foam, TermoZvukoIzol [8, 9]. The practical application of these materials revealed an insignificant acoustic effect as they are used to insulate impact noise.

However, in other industries there are several alternative solutions. In particular, composite bitumen- or adhesive-based vibration/noise absorbing materials are widely used in automotive industry [8 - 12]. The important parameter for these materials is mechanical loss factor. It indicates how efficiently the installed vibration absorber reduces vibrations and, as a result, how low the level of structure-borne noise emission is decreased. The factor can be from 0 to 1 where 0 means that material fails to dampen noise, 1 – no vibration, noise emission [10 - 13].

2. Materials and methods

The multimethod research was performed to study noise/vibration absorbing polymer composite materials as materials that increase acoustic comfort. The subjects of research were as follows:

- 1) 20 mm thick Volna polyurethane foam [14];
- 2) 4 mm thick foil-covered (60 μm) Isolon PE foam + 1.5 mm putty layer [15];
- 3) 8 mm thick foil-covered (60 μm) Isolon PE foam + 1.5 mm putty layer [15];
- 4) 5 mm thick bitumen impregnated polyurethane foam [16];
- 5) 9 mm thick foam rubber [16];
- 6) 14 mm thick foam rubber [16].

The comprehensive assessment of vibration/sound absorbing properties was performed using the measured values of mechanical loss factor and sound absorption coefficient (K_3).

The mechanical loss factor was determined with the vibroacoustic equipment by Brüel & Kjær (Denmark) using the method: Bitumen pads. Method of loss factor definition. RD 37.012.008-88 [17]. The mechanical loss factor was determined for the samples with different effective lengths (160 mm, 170 mm, 180 mm). In order to determine the loss factor at a frequency of 200 Hz, the graphs were plotted according to point 5.4, procedure [17]. The measurement results are shown in the table below.

The sound absorption coefficient K_3 was determined with Brüel & Kjær impedance tube, type 4206 according to GOST 16297-80: Sound insulation and sound absorption materials. Methods of testing [18 - 19]. The measurement results are shown in the table below.

Analysis of the results revealed that thickness of the material was the most important parameter that influenced sound absorbing properties of the samples (samples 3, 5, 6). A significant increase in K_3 was observed in the samples with a thickness of 9 mm and higher. As the materials themselves cannot provide a finish-ready hard wall they should be covered with a plasterboard.

With regard to their sound absorption coefficient K_3 , the Russian materials are getting closer to the current foreign materials with high sound absorbing properties: micro-perforated stretch ceiling by Clipso (Switzerland) [20]. The ability to make considerable modifications in the composition and structure makes it possible to design acoustic fire-retardant biostable materials with low water absorption in the future. High adhesion due to adhesive layer will facilitate attachment to various surfaces, including those of complex shape (pipelines, ventilation systems, etc.), a wide range of operating temperatures (from -40 °C to +70 °C) will allow the materials to be used in all climate zones in Russia.

3. Results and discussion

Table. Vibration and sound absorption performance of polymer composite materials *

Parameter	Sample 1**	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Mechanical loss factor (at 200 Hz)	-	0.110	0.117	0.014	0.040	0.028
Frequency	K_3					
100	0.067	0.036	0.043	0.046	0.037	0.052
125	0.049	0.018	0.027	0.028	0.018	0.038
160	0.064	0.033	0.042	0.042	0.031	0.054
200	0.067	0.034	0.045	0.042	0.032	0.061
250	0.073	0.038	0.052	0.046	0.039	0.076
315	0.079	0.041	0.061	0.048	0.043	0.087
400	0.085	0.044	0.065	0.049	0.047	0.106
500	0.082	0.046	0.041	0.065	0.028	0.134
630	0.100	0.065	0.099	0.052	0.051	0.169
800	0.117	0.094	0.136	0.053	0.058	0.231
1000	0.152	0.170	0.190	0.055	0.072	0.341
1250	0.216	0.220	0.168	0.106	0.116	0.487
1600	0.215	0.125	0.303	0.102	0.313	0.621
2000	0.287	0.099	0.129	0.056	0.176	0.726
2500	0.398	0.111	0.122	0.067	0.274	0.719
3150	0.573	0.141	0.146	0.089	0.571	0.688
4000	0.729	0.170	0.256	0.145	0.578	0.568
5000	0.805	0.227	0.299	0.149	0.356	0.550
6300	0.819	0.239	0.416	0.225	0.236	0.485

* - samples were tested not on the side of adhesive layer.

** - sample 1 was used as reference.

4. Conclusion

Therefore, acoustic comfort can be achieved using the Russian vibration/sound absorbing polymer composite materials without sacrificing significant space.

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