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EXPERIMENTAL TEST OF ACOUSTIC PROPERTIES OF INTERNAL WALL CONSTRUCTION ELEMENTS

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Abstract. Since external noise outdoors is growing, residents more and more often complain for poor sound insulation of new buildings. Walls separate premises from external or internal space. Their purpose is to hold heat and to let no noise go from one premises to another. Along with changing traditions, thinner partitions being used, they are often built using small keramzit blocks with filled and unfilled air gaps. Partitions are coated with plaster cardboard tiles or are plastered all over.

The sound insulation factors R_w of double keramzit block partition were investigated. Air gaps of the partition were filled fully and partially with rock wool; its surface was plastered and smoothed.

Research of acoustic properties of various constructions showed that the partition with uncoated by extra materials surface and fully filled air gap had the worst properties. Best performance was realized when the air gap of the partition was filled with 50 mm rock wool layer, leaving 50 mm empty.

Keywords: partition of internal premises, noise, preventing noise from propagation.

1. Introduction

In order to suppress noise inside, double-structured walls have been widespread, because they feature better noise insulation properties compared with the single-structure walls. [1-4].

However the double-structure wall often insufficiently insulates noise in the range of low frequencies due to the sound resonance originating in the air gap located between the two walls. [5-7].

Filling the air gap in the wall with noise-absorbing material rarely helps to suppress the noise in the range of low frequencies [8-9].

Using loudspeakers for control inside the gaps, De Fonseca et al. experimentally proved that active noise transfer reduction may be reached by reducing energy passing through the gap [3].

In the most of practical situations double-wall structures have to contain mechanical links, connecting the two connected walls together. However the links, connecting the walls, serve as energy transfer path; inseparable connection between the wall plates can significantly amplify noise passing through the wall [10-11].

Currently partitions are often made of keramzit blocks, featuring light weight and good heat insulation properties. In the paper acoustic properties of double keramzit wall with filled air gap are examined.

2. Research methods

Materials' acoustic properties are researched in an echo-free sound suppression chamber of Vilnius Gediminas Technical University, Environment Protection Chair. Total length of the chamber is 4 m, width 2,4 m, height 3 m. Total area of the internal surface (walls, floor, ceiling and partition) makes 70 m^2, which is covered with plates of cut acoustic porolon layer of 0,25 m (cutting step 0,15 m.).

Echoing chambers are insulated in relation to each other and in relation to external building with the means of rock wool panels. Such construction enables reduction of indirect sound transfer between the echoing chambers. The wall separating the echoing chambers, has a hole of 1 m^2, where the test sample sized 1,0 m x 1,0 m is fastened rigidly.

In order to analyse the acoustic properties of constructions in the noise chambers, Danish measuring apparatus was used. Apparatus consists of:

Real time sound spectrum analyser Bruel&Kjaer mediator 2260;

Microphone 4189 – Bruel&Kjaer (2 pcs);

Power amplifier Bruel&Kjaer (power: 300 W);

Single-direction source with twelve loudspeakers – Bruel&Kjaer (frequency characteristics 100 Hz to 3 150 Hz) with a tripod adjustable in height 1,3 to 2,0 m.

Apparatus has two measurement channels, so sound can be measured with two microphones at a time, which are located in different spots. With the help of integrated processor and special software the apparatus performs statistical processing of the measurement results.

Measurement method for the partitions' insulation factor R_w of the sound, transferred in the air under lab conditions is given according to standard LST EN ISO 140-3. White and pink noises are used during the tests.

Pink noise values, differently from white noise, in the low frequencies are higher up to 15 dB.

Test sample (sized 1,0 m x 1,0 m) is installed into the hole of the partition wall located in the acoustic measurement chamber. Then the following parameters are measured for the installed test sample in 1/3 oct. frequency band (ranging 100 Hz to 3150 Hz):

- Average sound pressure level in the sending area (at an average 10 measurements).
- Average sound pressure level in the receiving area (at an average 10 measurements).
- Average standard reverberation time in the receiving area.

Measurements are carried out in the acoustic measurement chamber with sending and receiving sound area premises having the following dimensions:

- Width 2,5 m;
- Length 1,90 m;
- Height 2,60 m;
- Volume 12,35 m ^{3}

The test sample installed in the measurement chamber partition wall forms contact surface $S_p \approx 1{,}00\ m^2$ between the both premises. In the primary and secondary premises 5 microphone measurement spots are used with two locations of sound source, emitting sound into all directions in the primary premises. This totally makes 10 situations of measuring spots. After having calculated average sound pressure for all the spots, diffusion sound field conditions are provided in each premises.

Sound level reduction after passing through the sample is analysed in the average geometry frequency band as well as noise insulation factor R_w.

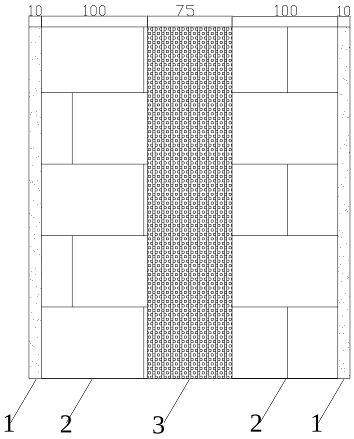

Fig 1. Test wall construction.

1 - plaster, 10 mm; 2 – keramzit blocks "FIBO" (3 MPa), (100×185×490); 3 – rock wool "Paroc", 75 mm

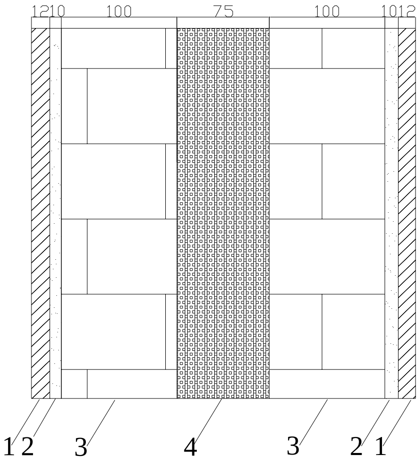

Fig 2. Test wall construction.

1 – plaster board panel, 12 mm; 2- plaster, 10 mm; 3 – keramzit blocks „FIBO" (3 MPa), (100×185×490); 4 – rock wool „Paroc", 75 mm

Acoustic tests were performed:

a) having installed a double-layer wall in the test chamber from keramzit 3 MPa blocks with air gap filled with 75 mm rock wool and 10 mm plaster layer;

b) having covered the wall additionally from the both sides with 12 mm plaster board panels;

c) having installed double-layer wall in the test chamber with 50 mm air gap and 50 mm rock wool layer and having plastered the wall from the both sides with 15 mm plaster layer;

d) having smoothed the wall from the both sides with extra putty layer of 2 mm;

e) having covered the wall in the silent side of the chamber with plaster cardboard panel

Schemes of the walls prepared for the test are given in figures 1-5.

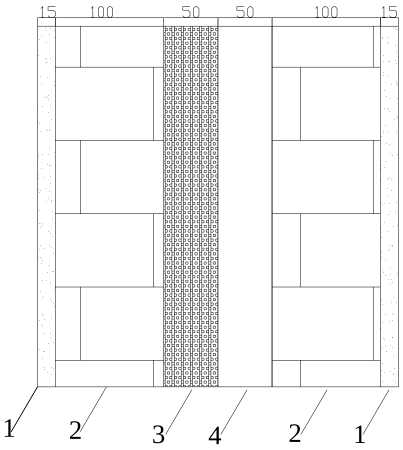

Fig 3. Test wall scheme.
1 – plaster, 15 mm; 2 – keramzit blocks „FIBO“ (3 MPa), (100×185×490); 3 – rock wool „Paroc“, 50 mm; 4 – air gap, 50 mm

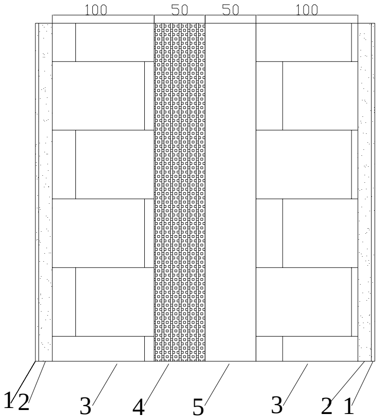

Fig 4. Test wall scheme.
1 – putty, 2 mm; 2 – plaster, 13 mm; 3 – keramzit blocks „FIBO“ (3 MPa), (100×185×490); 4 – rock wool „Paroc“, 50 mm; 5 – air gap, 50 mm

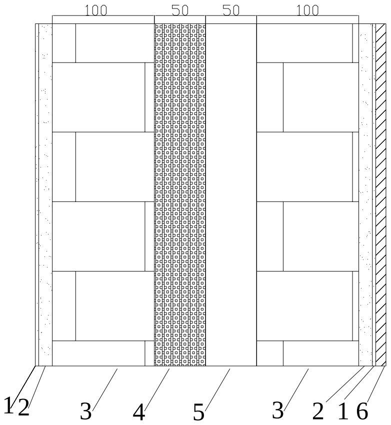

Fig 5. Test wall scheme.
1 – putty, 2 mm; 2 – plaster, 13 mm; 3 – keramzit blocks „FIBO“ (3 MPa), (100×185×490); 4 – rock wool „Paroc“, 50 mm; 5 – air gap, 50 mm; 6 – plaster cardboard.

3. Test results

First test was carried out after having installed double keramzit block wall in the chamber, and having filled the gap between the blocks with 75 mm rock wool layer, as depicted in figure 1.

Insulation and acoustic properties of the wall installed are tested using white noise. Noise insulation factor R_W of the tested wall as per figure 1 was 42 dB.

In the case of low frequencies (100 Hz to 400 Hz) noise level is reduced least, 21 dB, frequency 100 Hz, largest noise reduction of 42 dB is obtained at 400 Hz frequency. Test results are plotted in figure 6.

At average frequencies (500 to 1000 Hz) noise level is reduced from 37 to 45 dB.

The wall featured the best noise absorption at high frequencies, where the noise level reduces from 43 dB at frequency 1600 Hz, to 56 dB at 2500 Hz.

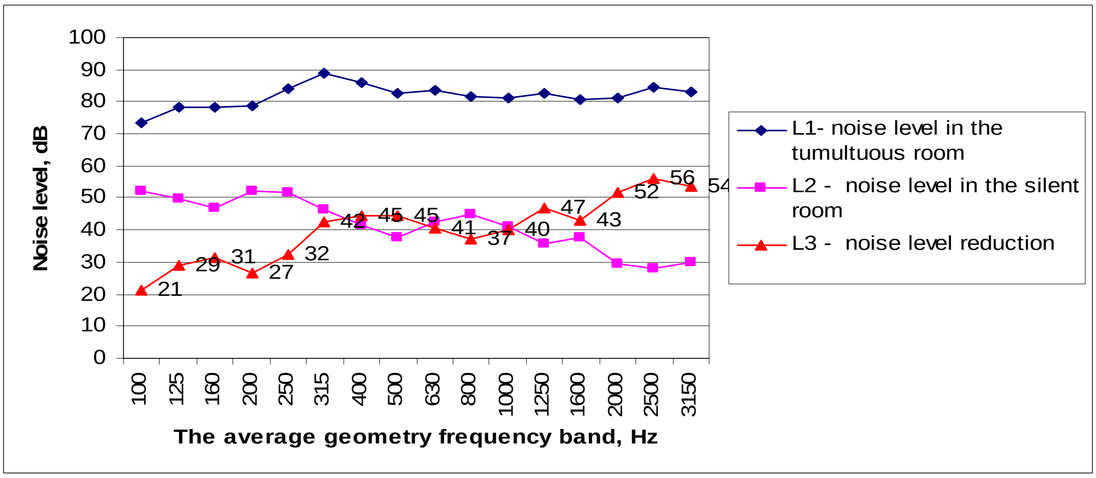

Fig 6. Noise level reduction in the average geometry frequency band, having filled the gap between the keramzit blocks with 75 mm rock wool layer and covered the blocks from exterior with 10 mm plaster layer

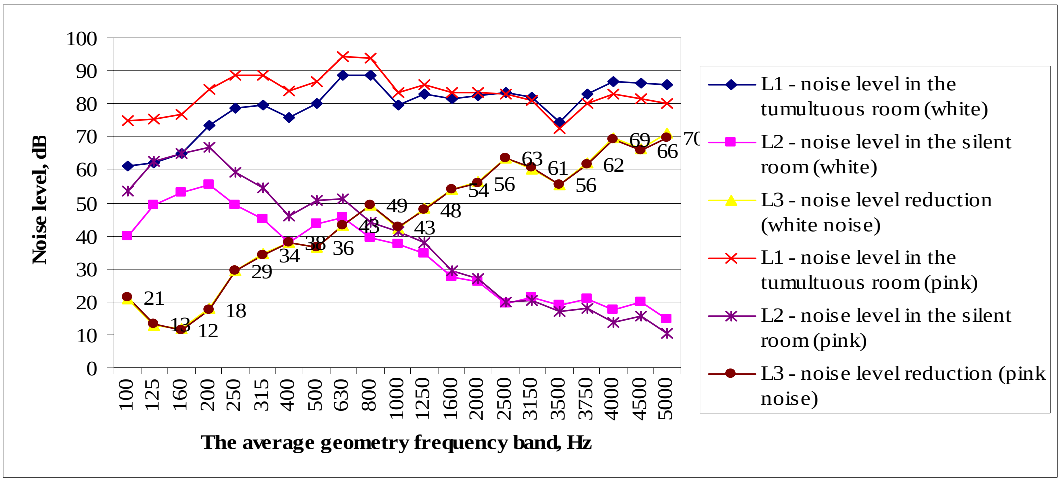

Fig 7. Noise level reduction in the average geometry frequency band, having filled the gap between the keramzit blocks with 75 mm rock wool layer and coated the wall with plaster cardboard panels from the both sides.

After having covered the wall depicted in Fig1 from the both sides with plaster cardboard panels, as per Fig2, its insulating properties were tested applying white and pink noise, test results are given in Fig7. The measured noise insulation factor reached 48 dB with the white and pink noise applied for the test. Though the pink noise up to 15 dB had higher values at low frequencies, wall noise absorption was the same in the case of white and pink noise.

Lowest noise insulation of 12 – 13 dB was obtained at 125 - 160 Hz frequencies; in the medium frequency band 500 – 1000 Hz noise insulation varied from 36 to 49 dB. Largest reduction in the noise level was obtained at 800 Hz frequency and reached 49 dB. At high frequencies noise level insulation grew up from 43 to 63 dB. Higher noise level insulation up to 70 dB was received at high frequencies 4000 – 5000 Hz.

Though pink noise has larger values at low frequencies, wall insulation remains the same as for the white noise throughout full frequency range. Later tests were carried out using white noise only.

After having installed a wall made of two keramzit blocks in the test chamber with 50 mm air gap and 50 mm rock wool layer (Fig 3), measured noise insulation factor R_w reached 53 dB.

Wall test results are plotted on Fig8. Wall with empty air gap and rock wool layer featured 11 and 9 dB higher insulation factor than the walls with earlier tested constructions. This wall also featured better noise insulation at lower frequencies; at frequencies 125 to 400 Hz noise was reduced from 20 to 54 dB. Highest noise insulation was obtained at frequency 315 Hz and reached 54 dB. However no further reduction in noise level was observed at low frequency 100 Hz.

At average frequencies 500 to 1000 Hz noise level was reduced from 51 to 63 dB.

At high frequencies 1250 to 3150 Hz noise level was reduced 59 to 66 dB. Largest noise level reduction was obtained at frequency 3150 Hz.

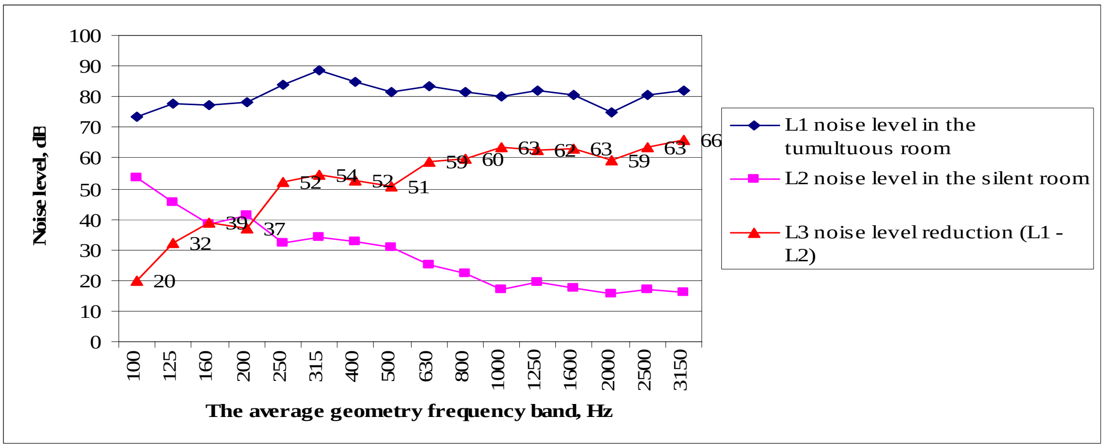

Fig 8. Noise level reduction in average geometry frequency band, having filled the gap between keramzit blocks with 50 mm rock wool layer leaving 50 mm air gap and then having plastered the wall from the both sides.

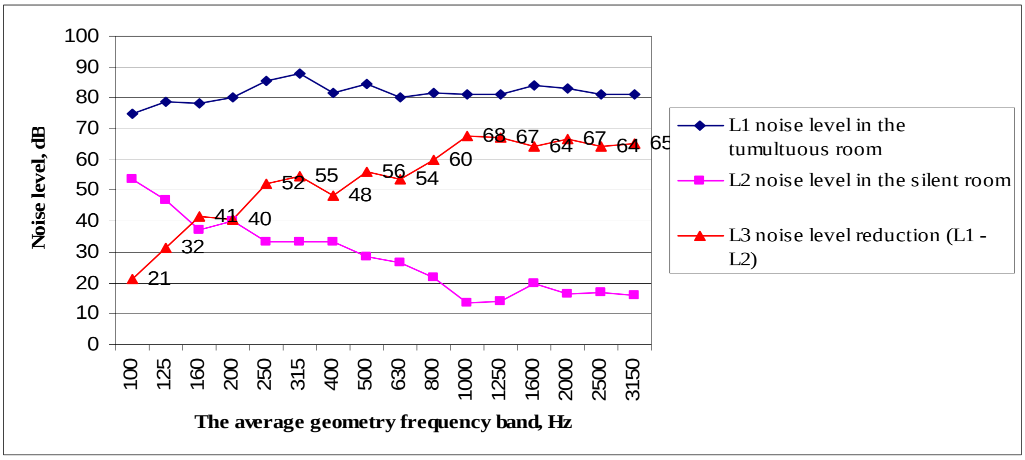

Fig 9. Noise level reduction in average geometry frequency band, having filled the gap between keramzit blocks with 50 mm rock wool layer leaving 50 mm air gap and then having plastered the wall and smoothed it with putty from the both sides.

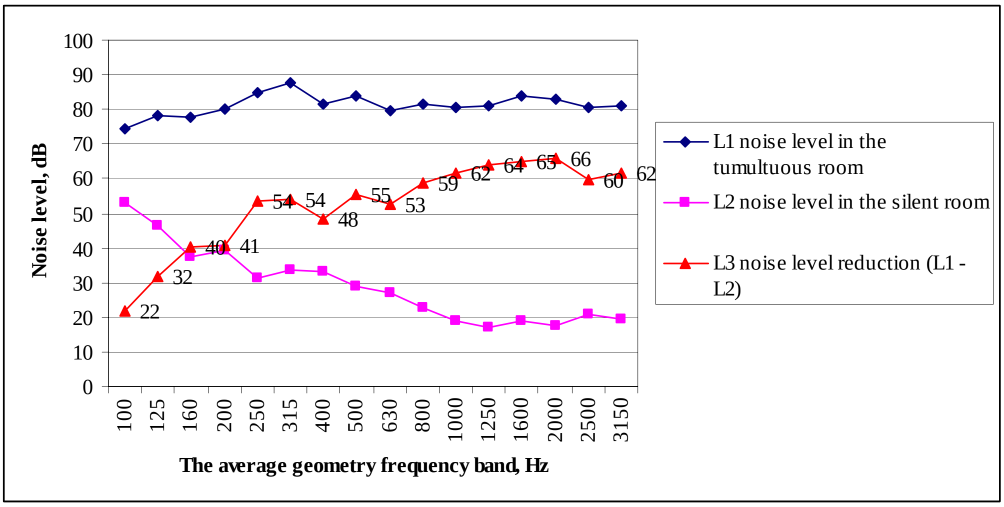

Fig 10. Noise level reduction in average geometry frequency band, having filled the gap between keramzit blocks with 50 mm rock wool layer leaving 50 mm air gap and then having plastered the wall and smoothed it with putty from the both sides, covering the silent side with plaster cardboard panel.

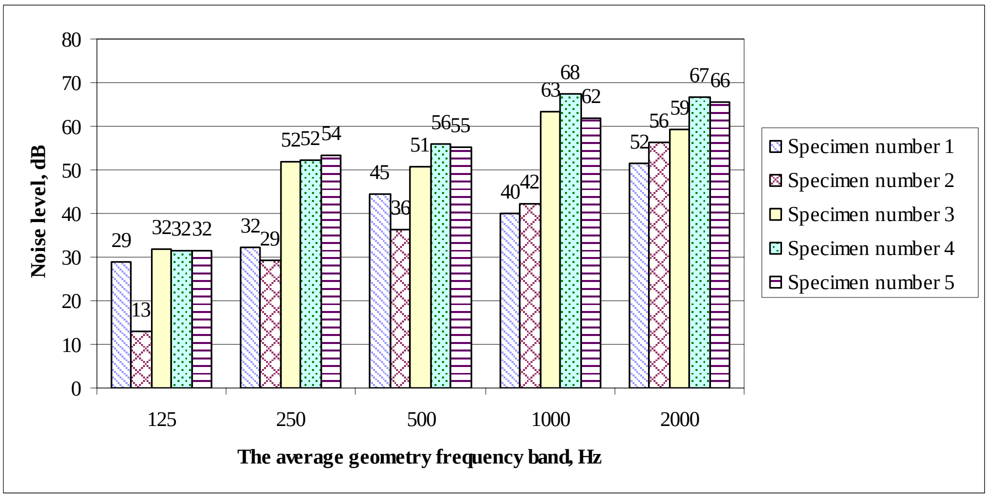

Fig 11. Noise level reduction in average geometry frequency band, using different partitions

After having installed the wall as depicted in Fig 3 and smoothed plaster from the both sides with 2 mm putty layer, measured noise insulation factor R_w reached 54 dB, i.e. noise insulation factor increased by 1 dB. Test results are plotted on Fig9.

At low frequencies 100 to 400 Hz, noise was reduced from 21 to 55 dB. At average frequencies 500 to 1000 Hz, noise absorption reached 51 to 68 dB, and at high frequencies (1250 to 3150 Hz) noise level was reduced to 68 dB.

After having puttied the wall with 2 mm putty layer from the both sides, its noise absorption improved at low frequencies up to 4 dB, noise insulation improved up to 4 dB at high frequencies, compared with the earlier tested walls.

After having covered the wall from silent side with plaster cardboard panel, noise insulation factor R_w reached 54 dB. Test results are plotted on Fig10. Noise level at low frequencies is reduced from 22 to 54 dB, at average frequencies noise level is reduced from 55 to 62 dB, and at high frequencies noise level is reduced to 66 dB (frequency 2000 Hz).

Data from Fig 11 shows that at low frequencies 125 and 250 Hz the partitions with 50 m air gap and 50 mm rock wool layer performed best.

At frequency 500 Hz highest reduction in the noise level by 55 and 56 dB is obtained when the gap between the keramzit blocks is filled with 50 mm rock wool layer, leaving 50 mm air gap, plastering the wall and smoothing it with putty from the both sides, also covering the wall from the silent side with plaster cardboard panel as depicted in Fig 4 and 5.

At frequency of 1000 Hz largest noise reduction of 68 dB was showed by the wall with its gap between the keramzit blocks filled with 50 mm rock wool layer and 50 mm air gap left, having plastered and smoothed the wall with putty from the both sides; and the least noise level reduction of 40 dB was obtained at filling the gap between the keramzit blocks with 75 mm rock wool layer and covering the blocks from exterior with 10 mm plaster layer.

At frequencies of 2000 Hz largest noise reduction to 67 dB was showed by the wall with its gap between keramzit blocks filled with 50 mm rock wool layer and 50 mm air gap left, having plastered the wall and smoothed it with putty from the both sides, and the least noise level reduction of 52 dB was obtained having filled the gap between the keramzit blocks with 75 mm rock wool layer and covered the blocks from exterior with 10 mm plaster layer.

4. Conclusions

1. At low frequencies (250 Hz), noise was reduced to 32 dB by the walls with the gap filled with 50 mm rock wool and 50 mm air gap between the blocks.
2. At low frequency of 250 Hz worst of all, to 29 dB, noise was reduced by a wall with the gap between the blocks filled with 75 mm rock wool layer and covered from the both sides with plaster cardboard panel.
3. At frequency 500 Hz highest noise level reduction by 55 and 56 dB was obtained with the wall with the gap between keramzit blocks filled with 50 mm rock wool layer, leaving 50 mm air gap, having plastered and smoothed the wall with putty from the both sides and covered the wall from the silent side with plaster cardboard panel.
4. At frequency 1000 Hz highest noise level reduction to 68 dB was obtained with the wall with the gap between keramzit blocks filled with 50 mm rock wool layer, leaving 50 mm air gap, having plastered and smoothed the wall with putty from the both sides, the lowest reduction in noise level by 40 db was obtained with the wall with the gap between the blocks filled with 75 mm rock wool layer and covered the blocks from exterior with 10 mm plaster layer.
5. At frequency 2000 Hz highest noise level reduction to 67 dB was obtained with the wall with the gap between keramzit blocks filled with 50 mm rock wool layer, leaving 50 mm air gap, having plastered and smoothed the wall with putty from the both sides, the lowest reduction in noise level by 52 dB was obtained with the wall with the gap between the blocks filled with 75 mm rock wool layer and covered the blocks from exterior with 10 mm plaster layer.
6. The walls of any construction best of all insulated noise at high and average frequencies and worst of all at low frequencies.

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