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Comparison of sound insulation of windows with double glass units

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ABSTRACT

Level of external noise grows every day in modern cities. New buildings usually have large windows or the whole areas of glass walls therefore protection from external noise is very important. Façade with good sound insulation properties is required to ensure acceptable internal noise level. Sound insulation of façade mainly depends from sound insulation properties of insulated glass unit (IGU). Different IGU with double, triple or even tetra glass could be used. In this paper is presented experimental study of window with three different type double glass units: 1 – two ordinary glass; 2 – one glass ordinary second one laminated; 3 – two laminated glass. The experimental results showed that sound reduction index (R) values are lower than 30 dB below frequency of 315 Hz (first type IGU), 250 Hz (second type IGU) and 125 Hz (third type IGU); sound reduction index (R) exceeds 45 dB above frequency of 4000 Hz (first type IGU), 2500 Hz (second type IGU) and 1600 Hz (third type IGU).

1. Introduction

Every day the level of noise from different sources (cars, trains, planes, industry, lawn mowers, leaf blowers, etc.) grows in both urban and suburban areas of cities [1,2]. Therefore protection from external noise is becoming a top priority to ensure acoustical comfort in buildings [3,4]. We cannot reduce the external noise level but we can reduce internal noise level by choosing appropriate facade construction with good sound insulation properties. Façade design task is difficult because modern buildings as a rule have big windows or even whole glass walls [5]. Façade sound insulation is divided into active and passive façade sound insulation [6,5,7–12]. The best passive sound insulation solutions are double glazing and laminated glazing solutions [4,5,13,14].

If we want to design façades with adequate sound insulation properties, we must know sound reduction index values (R) of windows tested in the laboratory. The sound reduction index of windows depends from various subjects as: type of glass, dimensions of glass, type of joinery, joints and seals in the window-opening system [3]. Windows and walls usually have double or triple glass units [3].

Double-glass IGU use two separate panes of glass with the gas (mostly argon) space between them. Such a double structure has a resonant frequency which depends on the mass of the panes and the distance between them as well as on the stiffness of the gas filling the cavity between panes [4,13]. The sound reduction index of a double glazed system at low frequencies can be considered as two masses acting together as a single pane with the same total mass. As the frequency increases, the airspace separating the glass panes acts as a spring [3].

The experimental results of the sound reduction index for the different types of windows with double glass units are presented. In this experimental study three types of double IGU were tested: first type – two ordinary glass; second – one ordinary and one laminated; third – two laminated glass. The aim of the experimental study was to determine which window has the highest value of weighted sound reduction index (R_w), and which has the best sound insulation at a low frequency range (below 400 Hz).

2. Test methodology, equipment and samples

The measurements of the experimental study were done in 1/3 octave bands from 100 Hz to 5000 Hz according to LST EN ISO 10140 series standards part 1, 2, 4 and 5 [15–18]. Measurements results were evaluated according to LST EN ISO 717-1 standard [19]. A combination of three loudspeaker and six microphone positions were used for measurements. The measurements were performed in the acoustic laboratory at Kaunas University of Technology in the period January–May of 2014. The temperature and relative humidity were kept constant (respectively 18 °C and 50%) and was controlled using a relative humidity and temperature sensor "Testo 615". The measurement system consists of two microphones L&D (Larson & Davis) 2560; two initial microphone

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amplifiers L&D PRM 900C; precision integrated noise spectra meter – noise generator L&D 2800B; loudspeaker, power amplifier and rotating microphone system were made at Kaunas University of Technology. The accuracy of the equipment used for the measurements is verified in an accredited metrology laboratory.

The acoustic laboratory has masonry walls of ceramic bricks with mineral wool interlayer. There are two chambers: source chamber (volume 79.95 m^3) and receiving chamber (volume 68.56 m^3) (Fig. 1).

Between chambers is a separating wall (area 11.7 m^2) with sound insulation $R_w = 75$ dB. In the wall is an opening for the window (dimensions 1500 × 1250 mm). The test window (1230 × 1480 mm) was installed in the opening (Fig. 2).

The frame and sash of the window is wooden (pine) 78 mm thick covered with aluminum from the outside (source chamber); binding GU UniJet; gaskets – SP33 and SP6854; fixing – 8 points (Fig. 3).

The window in the opening was fixed with wooden sticks during the measurements. The perimeter (gap between frame and wall) was sealed using special high density material – Perrenator – from both sides. The same window frame was used for all the tests changing only IGU inside of it.

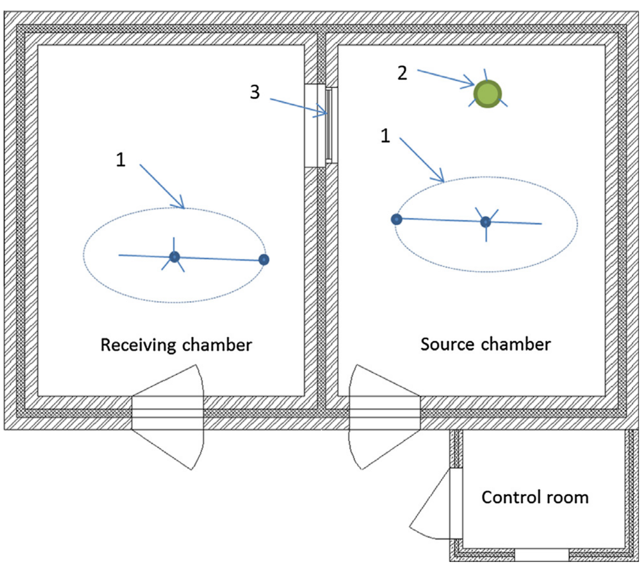

Fig. 1. Plan of acoustic laboratory. 1 – rotating microphone system; 2 – sound source; 3 – test window.

The insulated glass units used for measurements are given in the Table 1.

Twelve double glass units were tested: four were both of panes ordinary glass (WOG2); four with one ordinary and one laminated glass pane (WOLG1); four where both glass panes were laminated (WLG2). The thickness of ordinary glass varied from 4 mm to 12 mm, laminated glass – from 8 mm to 12 mm, the thickness of the air gap from 18 mm to 27 mm and the thickness of glass unit – from 28 mm to 48 mm. All spacers between glasses were metallic except the acoustic one, which was made from rubber. The laminated glass had special acoustical PVB interlayer,–one layer (test samples WOLG1) and two layers (test samples WLG2). All IGU were filled with argon gas. The test samples were made in LLC "Doleta", Lithuania.

3. Test results and discussion

Presented below are the results of the performed experimental study with double glass units described above (Table 1). In Fig. 4 the graphical frequency dependences of sound reduction index in frequency range 100–5000 Hz of IGU with ordinary glass are presented.

From presented curves (Fig. 4) we can see that ordinary glass has poor sound insulation in low frequency range (below 315 Hz). Low values of sound reduction index at a low frequency range are conditioned by resonant effects of the system mass – gas – mass. From Fig. 4 we can see that the curve character in the analyzed frequency range is the same for tested windows with glass units WOG2/1 and WOG2/2 though the gap between glass panes in the second unit is 6 mm wider. By keeping the thickness of the gap 24 mm and increasing the thickness of the second glass pane by 2 mm (test sample WOG2/3) we do not get better sound insulation in this analyzed frequency range. Only for the test sample WOG2/4–6 mm thicker than test sample WOG2/2 we get 1–2 dB improvement of sound insulation. It shows that only three time difference of thickness of first and second glass gives little improvement of sound insulation in low frequency range. In the middle frequency range 400–2000 Hz sound reduction index values (R) are between 35 dB and 40 dB and curves character of all test samples are similar though different thickness glass were used. In this frequency range it (thickness) has no influence. In the high frequency range (above 2000 Hz) we get sound insulation decrement due to coincidence effect. For test samples WOG2/1–WOG2/3 decrement is almost the same (difference is 1–2 dB). While for the test sample WOG2/4 due to the shift of critical

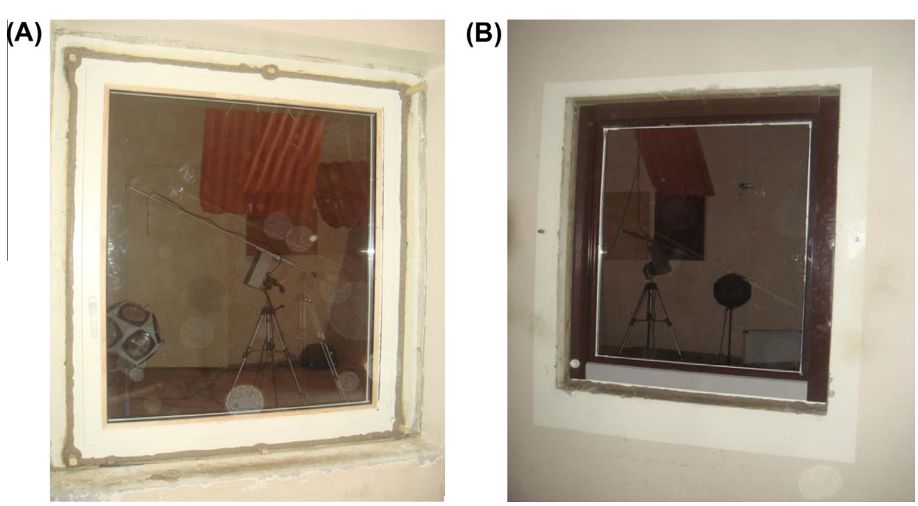

Fig. 2. Test window in the opening: (A) view from receiving chamber (inside of window); (B) view from source chamber (outside of window).