Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology № 88, 2014: 56-60
(Ann. WULS - SGGW, For. and Wood Technol. 88, 2014)

Non-normative method for determining acoustic insulation of board materials

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Abstract: *Non-normative method for determining acoustic insulation of board materials.* The paper presents a new method for the measurement of acoustic insulation against airborne sounds in the insulation and construction board materials used in wooden and brick buildings. The primary aim of the study was to simplify the design of a test stand, and thus of individual measurements, while maintaining the confidence level of the results. A series of measurements was performed to evaluate this method's suitability for determining the acoustic insulation of board materials, and the resulting sound reduction index was analyzed with reference to the tested material and frequency of the generated sound. The study outcomes were found to be consistent with the principles of building acoustics and allowed for drawing preliminary conclusions on the insulating properties of various board materials and sets of materials used for the construction of building partitions.

Keywords: acoustic insulation, wood-based materials, methods

INTRODUCTION

The primary functions of building partition walls include thermal insulation and acoustic protection against outside noise, sounds from adjoining rooms and technical equipment of a building. High level of environmental noise means that increasingly more attention is paid to the possibilities of reducing its impact on our everyday lives. Noise is most effectively muffled by walls made of heavy materials, such as concrete, bricks and fibrous insulating materials. To achieve the required level of sound protection in light wooden partitions, the principles of wall construction and joining, distances between the partition layers, partition layer flexibility, joint filling, etc., must be strictly followed already at the stage of building design and during actual construction (Bajdała 2011). The properties of individual construction and insulating materials are also important. Wood-based materials used in wood-frame construction, such as particle boards or oriented strand boards, are prone to vibrations that reduce the acoustic insulation of a partition wall. For this reason, new, often hybrid wood-based boards are manufactured, with improved physical and mechanical properties, combining wood and other materials. Therefore, it is important to determine their sound insulating properties in a quick and simple way. Current measurements of airborne sound insulation are based on EN ISO 10140-1:2010 standard. This standard describes laboratory methods for measuring airborne sound insulation of building elements such as floors, external walls and their components, as well as wall and floor systems with additional layers, e.g. suspended ceilings or raised floors. However, it does not apply to individual materials, such as construction or insulation boards. A serious problem with this type of research are requirements concerning the measurement conditions - the size of the investigated opening or the size and construction of test chambers, which implicate considerable costs and are time consuming to fulfil. For these reasons, attempts are made at determining the acoustic insulation of various systems and individual materials by using small-size test chambers, as described by Godinho (2010) and Branco and Godinho (2013). The aim of this study was to develop a simplified method for determining the acoustic insulation of board materials (especially wood-based boards), used for sheathing and insulation purposes. Moreover, we tried to evaluate a suitability of this method for comparing acoustic properties of selected board materials and systems used both in modern wood constructions and traditional masonry technologies.

MATERIALS AND METHODS

An outline of the test stand, used for determining airborne sound insulation of board materials, designed in the Department of Wood-Based Materials at Poznań University of Life Sciences, is presented in Fig. 1. It consists of two chambers with rectangular cross-section, i.e., a movable transmitting chamber and a stationary receiving chamber. The chamber walls were made of two 18 mm thick particleboards, separated with a thick layer of sound-absorbing polyurethane foam and multilayer high-density fiberboard that provided further excellent sound insulation. The inside of the chamber was lined with rubber to damp vibration resonance. The transmitting chamber was fitted with loudspeakers used for generating sounds of various frequency. The receiving chamber was fitted with a digital sound meter Sonometr DT-8852, connected to a computer equipped with a software for controlling, registering, measurements and data acquisition. A sample of the tested material was positioned vertically between the outlets of the chambers. Then, pneumatic actuators moved the transmitting chamber, pressing the sample against the outlet of the motionless receiving chamber.

When the test stand was ready, the sound meter was turned on, a sound signal was generated, and the level of maximum acoustic pressure in the receiving chamber, before and after mounting the tested sample, was determined. The measurements were performed at the following frequencies from the range provided in EN ISO 10140-1:2010 standard: 125, 250, 500, 1000, 2000, and 3150 Hz. The resulting values were used for defining specific sound reduction index R for each frequency, based on the following formula:

$$R = L_1 - L_2 + \log\frac{S}{A}\ [dB]$$

where:

L_1 – maximum sound pressure in the receiving chamber [dB]

L_2 – sound pressure in the receiving chamber after mounting the tested sample [dB]

S – sample surface of 0.5 [m^2]

A – absorbing surface of the receiving chamber amounting to 2 [m^2]

The measurements carried out using this method did not include the sounds transmitted on the side, which is why the study results cannot be directly extrapolated to field conditions and should also account for other factors affecting the acoustic insulation. The effect related to the method of mounting different boards in the partition construction was also neglected.

To determine a suitability of the developed method for acoustic insulation evaluation, a series of measurements was performed, involving sheathing boards and insulating materials commonly used in the construction industry. The tests included the following sheathing boards:

- 12 mm thick OSB/3
- 12 mm thick MFP
- 12.5 mm thick drywall

and insulating materials:

- 60 mm thick fiberboard, with a density of 265 kg/m^3
- 60 mm thick mineral wool, with a density of 180 kg/m^3
- 50 mm thick Styrofoam boards, with a density of 40 kg/m^3

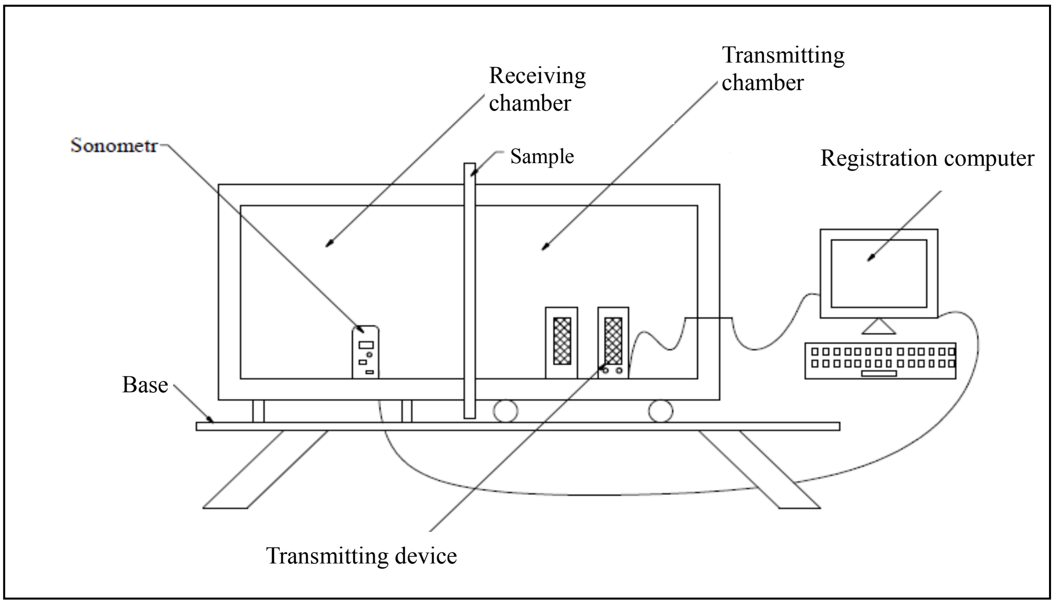

Fig.1. Test chamber for the measurements of acoustic insulation

RESULTS

The values of sound reduction index for different frequencies and selected sheathing and insulating materials used in wooden constructions are presented in Table 1, and combinations of these materials and cross-sections of walls made of them are showed in Tables 2 and 3. The resulting data indicate that the developed method of the acoustic insulation assessment yields results consistent with building acoustics principles, depending largely on the frequency of the generated sound, and density, thickness, porosity and dynamic stiffness of the materials. No significant changes in insulation parameters were observed in wood-based sheathing boards, but drywall showed better sound insulation properties, probably due to its higher density. Worth noticing is low sound reduction index of Styrofoam that was a few times lower than that of the other materials within the whole investigated frequency range. This demonstrates poor sound insulation properties of Styrofoam. Subject literature indicates that to effectively reduce noise level, Stryfoam needs to be combined with sheathing boards, e.g. drywall. The study showed that the best acoustic insulation, for both low and high sound frequency, was noticed in particleboards, characterized also by the highest density among all the investigated insulating materials.

Tables 2 and 3 contain the values of sound reduction index for sample systems used in the construction of stud walls. Inserting a porous insulting material, such as mineral wool or fiberboard, between the sheathing boards, largely improved a partition's acoustic insulation. This was particularly evident at high sound frequencies. A detailed analysis of the study outcomes included the values of sound reduction index determined at 500 Hz, the frequency that is the limit of mid band of the human hearing range.

This is also a reference value for the determination of sound reduction index of the construction materials and building partitions. The analysis showed a significant increase in the acoustic insulation value with increasing number of layers in the set. The highest value of acoustic insulation was calculated for the set comprising fiberboard as an insulating material. In the case of a set comprising two drywall panels and a fiberboard, the difference in this parameter, when compared with mineral wool, was as high as 13 dB. A similar difference was found for the set made up of OSB/3 and a drywall panel. Such a significant improvement in acoustic insulation properties in the sets comprising fiberboard undoubtedly stems from the fibrous structure of this material and its relatively high density. This is consistent with the assumption that the best sound insulation effects are achieved by combining porous and high density materials.

Table 1. The values of sound reduction index for the investigated materials

Frequency [Hz]	Sheathing materials			Insulation materials		
	OSB/3	MFP	Drywall	Fiberboard	Mineral wool	Styrofoam
	Sound reduction index [dB]					
125	14.5	15.1	15.1	17.6	15.0	2.8
250	15.0	16.5	14.2	18.9	14.5	2.1
500	**17.0**	**16.6**	**18.1**	**23.7**	**24.2**	**8.0**
1000	16.3	18.1	19.5	27.7	26.9	6.6
2000	18.7	19.9	20.1	29.6	28.0	9.1
3150	19.9	20.5	20.8	32.7	30.8	8.6

Table 2. Acoustic insulation of combined materials - drywall

Frequency [Hz]	Set		
	2 x drywall	2 x drywall + mineral wool	2 x drywall + fiberboard
	Sound reduction index [dB]		
125	20.6	25.1	26.8
250	17.1	26.0	31.4
500	**23.9**	**33.4**	**43.4**
1000	25.0	37.6	44.2
2000	26.7	36.1	52.3
3150	27.3	34.3	50.2

Table 3. Acoustic insulation of combined materials - OSB/3

Frequency [Hz]	Set		
	OSB/3 + drywall	OSB/3 + drywall + mineral wool	OSB/3 + drywall + fiberboard
	Sound reduction index [dB]		
125	21.4	26.9	26.7
250	30.7	39.0	40.9
500	**26.1**	**29.2**	**39.0**
1000	31.9	30.2	45.4
2000	35.2	44.2	55.2
3150	35.9	40.2	54.6

CONCLUSIONS

In summary, it can be concluded that the developed method is suitable for comparative measurements of airborne sound insulation of wood-based and other materials. The obtained values of the sound reduction index are consistent with previously described relationships between the frequency of the generated sound and the density, type and structure of the tested materials. Therefore, the described method enables a determination of approximate values of sound reduction index and allows for drawing preliminary conclusions regarding acoustic insulation of wall-like multilayer systems.

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Streszczenie: *Nienormatywna metoda wyznaczania izolacyjności akustycznej materiałów płytowych.* W pracy zaprezentowano nową, opracowaną przez autorów metodę pomiaru izolacyjności akustycznej od dźwięków powietrznych płytowych materiałów konstrukcyjnych i izolacyjnych stosowanych w budownictwie drewnianym i murowanym. Celem pracy było przede wszystkim uproszczenie stanowiska pomiarowego, a tym samym sposobu przeprowadzania pomiarów jednostkowych, przy zachowaniu poziomu ufności otrzymanych wyników. Dla określenia przydatności prezentowanej metody do wyznaczania izolacyjności akustycznej materiałów płytowych dokonano szeregu pomiarów oraz analizy wyznaczonego na ich postawie wskaźnika izolacyjności akustycznej w zależności od rodzaju badanego materiału i częstotliwości generowanego dźwięku. Stwierdzono, iż uzyskane wyniki badań są zgodne z zasadami akustyki budowli i pozwalają na formułowanie wstępnych wniosków odnośnie izolacyjności poszczególnych materiałów płytowych oraz ich zestawów w konstrukcji przegród.

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