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Verification of the impact of the used type of excitation noise in determining the acoustic properties of separating constructions

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ABSTRACT

When measuring the acoustic properties of building constructions, a chain generating excitation noise, in which a generator generates the chosen type of noise, is used. White or pink noise is most often utilised. Standard STN ISO 140-4 recommends using white noise, whereas standard STN EN ISO 717-1 recommends pink noise. No reasonable science-based recommendations for the choice of noise are known. This study elucidates the impact of noise on the measurements of acoustic properties of building constructions.
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1. Introduction

The issue of high levels of noise to which residents are exposed in residential areas is well known. New or renovated construction sites must comply with several terms to minimise the transfer of noise from the outside into a protected indoor environment, as well as the transfer of noise between two adjacent rooms. Since the legislation is becoming stricter, building acoustic measurements are required in most countries. These measurements are either experimental or operational, and white or pink noise is most commonly used for both types of measurement.

Several authors have already dealt with this issue. In 1976, Stephens in [1], started replacing the original method of measurement of airborne sound insulation of walls and ceilings in 16 third octave bands. He used a method of measuring the overall difference of sound pressure level using a sound level meter with a broadband source of white or pink noise. Gracey in [2] tried to point out the application of individual instruments by means of a multifunction microprocessor device, which included the possibility of interconnection with a generator of white and pink noise. Moreno in [3] described the influence of the spectral composition of noise and the shape of the curve on the results when assessing acoustic properties of building constructions. He stated that the type of noise transmitted and the shape of the transfer curve can have a considerable influence on the sound insulation values. Consequently the method used in measuring construction-acoustic properties influences the results, which is unacceptable. Ishihara compared the characteristics of white and pink noise and published his results in [4]. Evaluating his results, he used the well known AHP method. He presented the relationship between acoustic pressure and distance, and his experiment described the differences among characteristics of the used types of noise. Buratti et al. in [5] addressed the influence of

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different spectral compositions of traffic noise in laboratory and real conditions. In their paper, all 14 traffic noise spectra were tested in addition to the classic white and pink noise. Neubauer and Kang in [6] also compared different types of noise, including white and pink noise. When dealing with airborne sound insulation, they focused on comparing; values established by legislative requirements with values based on subjective perception of people. Tomašovič et al. in [7] analysed methods of construction-acoustic properties of buildings, and they listed an overview of methods used in the past. Their analyses were based on methods stated in the valid technical standards.

Despite the multitude of studies conducted in relation to this issue, previous authors have not come to any unambiguous conclusions and as such have not clarified the influence of the used type of noise on the evaluation of acoustic properties of building constructions. Therefore, with the current study, we strive to broaden the knowledge in this specific field.

2. Material and methods

2.1. Problem formulation

Valid technical standards define the exact methodology and determination of airborne sound insulation of building constructions. The result is a single variable which does not characterise acoustic properties in the whole frequency spectrum, even though it is based on it. When measuring, the type of source noise is chosen, and neither scientific methodology nor science-based recommendations are given when choosing the type of noise. White or pink noise is most often used, and these sources are considerably different in their spectral consistence. Building materials have different sound transmission characteristics in particular frequency bands. Therefore it is clear that the results of measurements can depend on the type of noise and it is necessary to investigate the possible influence of the type of noise on the resulting measurement. The scientific contribution consists in solving the issue of separating structures in the low frequencies. These are problematic in terms of sound insulation and current methodologies covered them only marginally. The aims set were the following:

- to clarify the influence of the type of noise used in measuring the acoustic properties of separating constructions on measurements,
- to analyse the influence of noise in the low frequency range. It are these frequencies that are present in residential areas and cause problems. The large wavelength impedes noise control measures and this type of noise bothers most residents in the indoor environment of buildings. Furthermore, measurements in the low frequency range are problematic.

2.2. Description of the experiment

The methodology designed for this experiment was partially based on the standard ISO 140-4. The degree of sound insulation was determined. Since this determination is a mathematical procedure, which has no influence on the noise source, the principle of determination was based on the airborne sound insulation of the building construction. This principle is illustrated in Fig. 1.

For the Apparent Sound Reduction Index R' it follows:

$$R' = L_T - L_R + 10\log\frac{S}{A} \qquad (1)$$

where L_T – is the mean sound pressure level in the transmitting room [dB], L_R – is the mean sound pressure level in the receiving room [dB], S – is the area of the wall specimen [m^2], A – is the absorption area of the receiving room.

For the experiment, the authors chose a wall which:

- was continuous without any holes or bumps,
- its construction was homogeneous, made of one type of material,
- was built with emphasis on uniform characteristics along the whole surface of the construction.

Since the research dealt with the influence of the noise type, acoustic properties were limited to determining the degree of sound insulation (level difference) D, which is characterises as the difference in the space and time averaged Sound Pressure Levels arising in both rooms under the action of one or more sound sources in one of them:

$$D = L_T - L_R \qquad (2)$$

Partial aim of the research was to verify the influence of the noise type at different levels of excitation. There were 6 bands of sound pressure levels in broadcast room when the measurements were conducted. The lowest band was in the range of 75–78 dB, the highest in the range of 98–102 dB.

In establishing the total effective absorption in the receiving room, we apply the Sabine Equation:

$$A = \frac{0.16V}{T} \qquad (3)$$

where V – room volume [m^3], T – reverberation time [s].

For this reason, the influence of the noise type on reverberation time was analysed as well.

In the research, it is very important to know the characteristics of the chosen types of noise [8,9].

White noise is a random signal (or process) with a flat power spectral density. In other words, in a homogeneous environment, the signal's power spectral density has equal power at any band, at any centre frequency, given a bandwidth. For example, a 20 Hz range between 40 and 60 Hz has the same power as the range of frequencies between 4000 Hz and 4020 Hz. White noise is the acoustic analogy to white light which contains each of the wavelengths of the electromagnetic spectrum.

An infinite-bandwidth white noise signal is purely theoretical. By having power at all frequencies, the total power of such a signal is infinite. In practice, a signal can be "white" with a flat spectrum over a defined frequency band (maximum in the range of audible sound or range established for practical structural–acoustic measurement). Fig. 2 shows the frequency spectrum of white noise.

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