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THE ROAD TRAFFIC NOISE ATTENUATION BY EXTERNAL WALL OF OFFICE BUILDING IN STANDARD WORK CONDITIONS

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Abstract

In many cases a road traffic noise is indicated by workers as one of basic factors of noxious work at office workplaces, so it is necessary to estimate it. There are few methods to estimate the road traffic noise at workplaces in the office buildings. Those methods are based on the results of noise assessment in the surrounding and sound insulation of external wall when the windows are closed. In those cases parameter which describes noise attenuation of the wall is sound insulation. The value of this parameter is quite this same as the value of the windows. But in standard work conditions the windows are often open, half-open, or untight. Therefore in order to predict SPL at the workplace in standard work conditions, it is necessary to take into account how the sound insulation of the external wall depends on the opening of the window.

1. INTRODUCTION

Noise at workstation in office buildings comes from:

- noise sources located inside the room (e.g. human activity, office equipment, ventilation and air-conditioning system),
- noise sources located inside the building, but in other rooms than the considered ones as well as noise sources located outside the building but connected with the building (lifts, ventilators);
- noise sources located outside the building (exterior sources).

The influence of the above mentioned noise sources on the resultant noise at a workstation depend on the sound power level of the individual noise sources and the noise attenuation during the propagation (from the sources to the workstation). Windows (elements of smaller sound insulation than the basic part of the outside wall) are the main way of the noise propagation from the outside to the inside of the building. When the windows are closed (typical conditions of noise assessment) the sound insulation of the outside wall is so big that the noise from outside of the building is negligibly small with relation to the noise from the sources located inside the building. However, when the windows are open, the attenuation of noise passing through the opening of the windows is small and then the noise from outside the building should be taken into account when determining the resultant noise at a workstation. Among the outside sources road traffic noise emitted by the cars is of the biggest influence on the resultant noise. Therefore the decrease of road traffic noise during the penetration to the building through the windows and the opening of the windows will be discussed.

In order to simplify the description the analysis will be limited to one quantity determining the properties of the sound insulation of the outside wall, further referred to as *the difference of levels* $\Delta L_{A,out\text{-}in,road}$. The value of this quantity will be determined (for the road traffic noise) by the difference of sound pressure levels measured simultaneously at two points: outside the building and inside the building, at a workstation (similar quantity used in the literature is defined as $D_{tr,2m}$).

This quantity will describe insulation properties of the external wall of the building to the penetration of road traffic noise from the outside to the inside (when the windows are closed and open) as well as the properties resulting from the propagation of the noise in the office room.

2. METHOD OF DETERMINING *THE DIFFERENCE OF LEVELS* $\Delta L_{A,OUT\text{-}IN,ROAD}$

The difference of levels $\Delta L_{A,out\text{-}in,road}$ is determined by the difference of sound pressure levels (in dB) measured at two points: outside the building, at 1 meter distance from the window and inside the building, at the workstation.

The subject of the research will be at what degree *the difference of levels* $\Delta L_{A,out\text{-}in,road}$ depends on the fact that the window is closed or open. In order to minimise the divergence (limit the number of elements influencing the measured quantities) all office rooms where measurements took place were of similar size and had similar equipment. Moreover it was assumed the workstations will be located 1 meter from the window. *The difference of levels* $\Delta L_{A,out\text{-}in,road}$ will be determined by the simultaneous measurement in the above mentioned measurement points, while preserving the negligible influence of other noise sources on the measured noise values.

The measurements will be conducted for each room with four variants of the “open” window (pic. 1):

- closed window,
- untight window,
- half-open window,
- open window.

3. THE RESULTS OF MEASUREMENTS

The research was carried out in 30 office rooms of the size ca. 3,5mx5mx3m=52,5m^3. The equipment was typical for offices (reverberation time fig. 1). The rooms had typical insulated windows in plastic frames with rubber seals (pic. 1). The area of the windows and openings for four measurement variants was the following:

- closed window (window area ca. 5.3 m^2)
- untight window (window area ca. 5.3 m^2, opening area 0.07m^2)

- half-open window (window area ca. 5 m^2, opening area 0.3 m^2)
- open window (window area ca. 3.9 m^2, opening area 1.4 m^2)

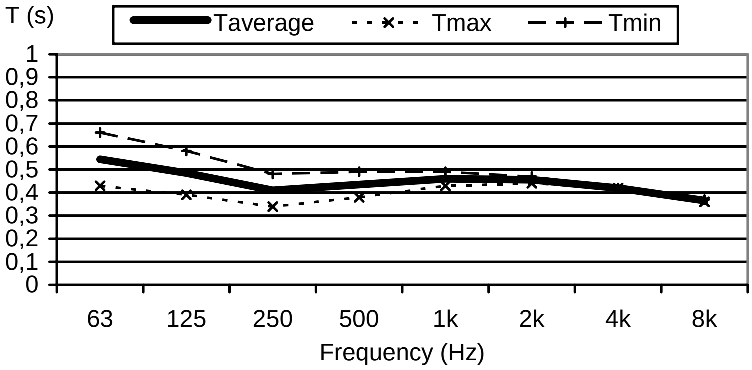
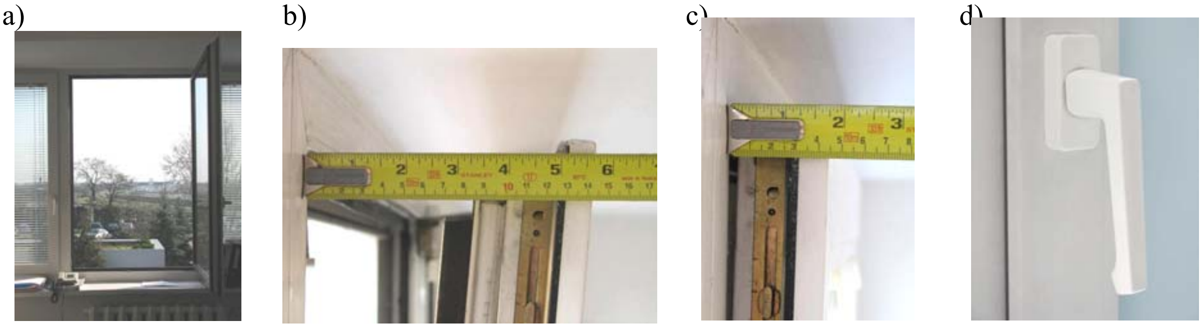


Figure 1. Reverberation time in octave bands.

Due to the technical possibility of conducting measurements and in order to minimise measurement mistakes:

- the largest number of measurements was carried out with half-open windows - the case in which the largest divergence between measurement results in individual rooms was expected,
- the smallest number of measurements was carried out with closed windows - the case in which the smallest divergence between measurement results in individual rooms was expected.

The measurements with closed and untight windows were conducted in a special way. In these cases, road traffic noise at workstations was very small due to thick facade insulation. In order to measure it in the presence of other noises (acoustic background), it was necessary to soundproof all internal sources of noise, while preserving the road traffic noise unchanged (high traffic intensity). Such results were obtained by conducting the measurements between 6 am. and 7.30 am., when most of the building installation could be turned off (the workers have not arrived yet) and with the highest traffic at the same time (workers were on the way to work).



Pic. 1 Four variants of the opening of the window: a) open, b) half open, c) untight,d) closed.

Figure 2 presents the results of A-weighted sound pressure levels measurements at measurement points located inside and outside of the building for all the examined rooms.

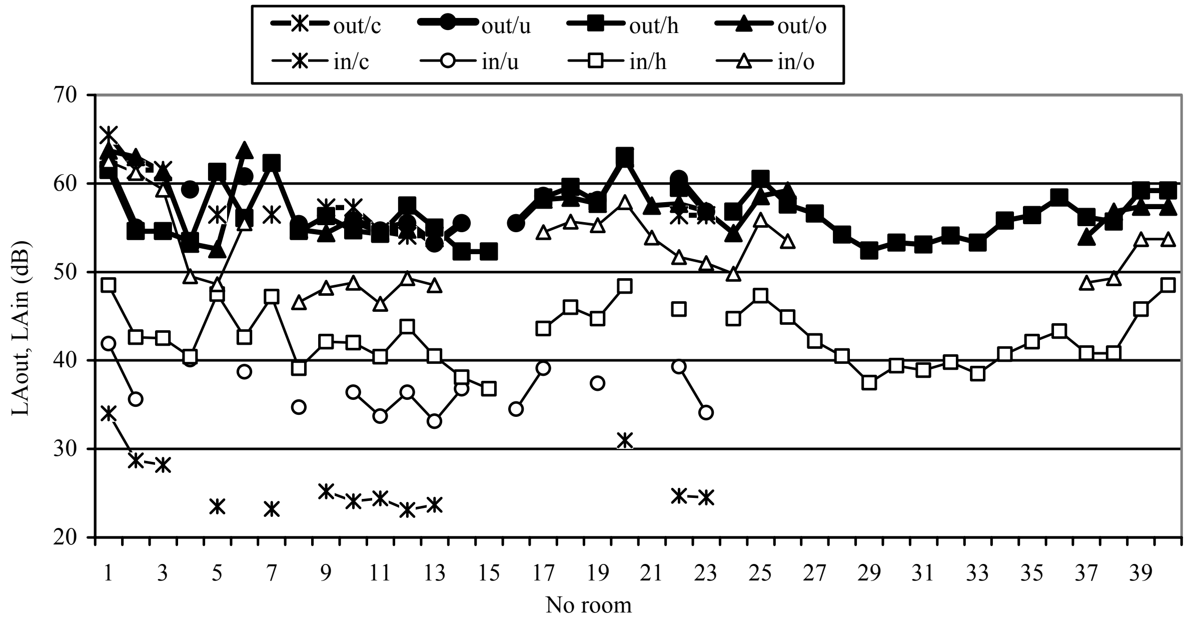


Figure 2. Results of A-weighted sound pressure levels measurements for all the examined rooms at measurement points located inside (L_{Ain}) and outside (L_{Aout}) of the building (window: *o*-open, *h*-half open, *u*-untight, *c*-closed).

Figure 3 presents the results of *the difference of levels* $\Delta L_{A,out\text{-}in,road}$ measurements for all the examined rooms and for four variants of the opening of the window.

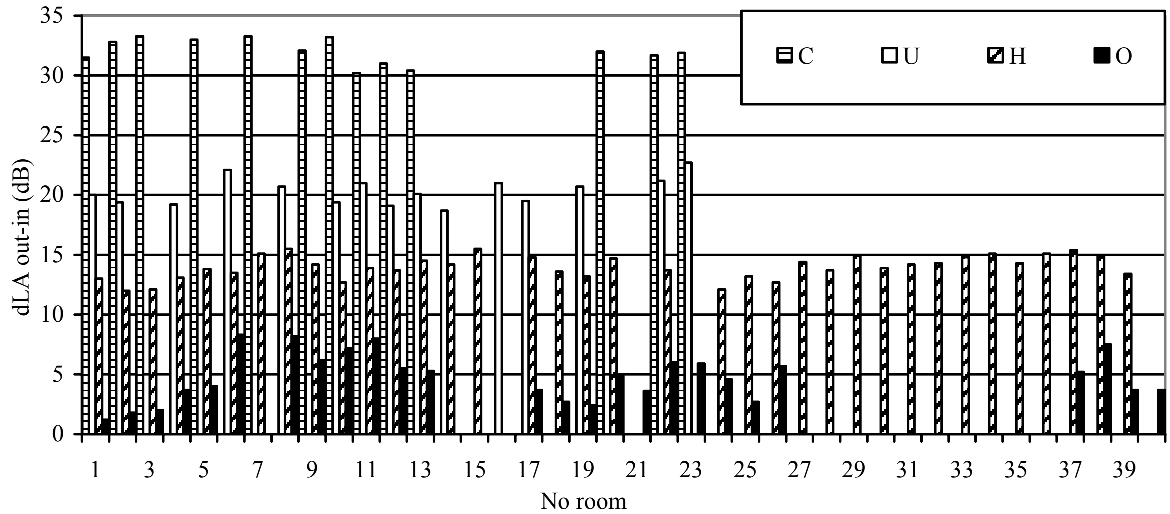


Figure 3. The results of *the difference of levels* $\Delta L_{A,out\text{-}in,road}$ measurements for all examined rooms for four variants of the opening of the window (window: *o*-open, *h*-half open, *u*-untight, *c*-closed).

Figure 4 presents the probability distribution of *the difference of levels* $\Delta L_{A,out\text{-}in,road}$ for all the examined rooms for the abovementioned four variants of the opening of the window.

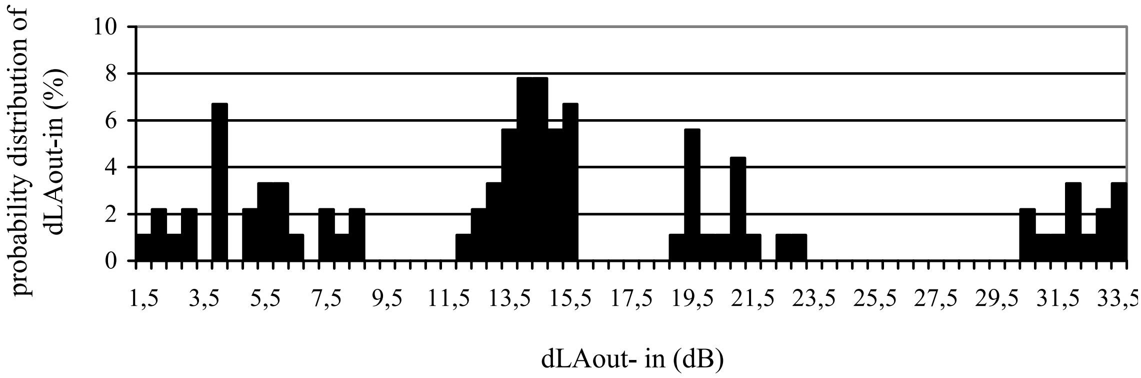


Figure 4. The probability distribution of measurement of *the difference of levels* $\Delta L_{A,out\text{-}in,road}$ for all examined rooms for four variants of the opening of the windows (open, half open, untight, closed).

The results of measurements have confirmed the expectations that probability distribution of measurement of *the difference of levels* $\Delta L_{A,out\text{-}in,road}$ is of tetra modal nature, i.e. the results of measurements are focused around four values resulting from four variants of the opening of the window.

Figure 5 presents the probability distribution of measurement of *the difference of levels* $\Delta L_{A,out\text{-}in,road}$ for all the examined rooms in case of closed windows.

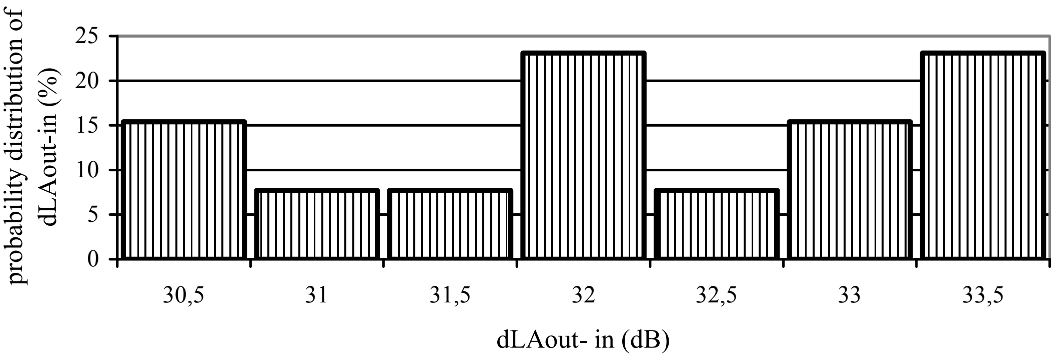


Figure 5. The probability distribution of measurement of the *difference of levels* $\Delta L_{A,out\text{-}in,road}$ for all examined rooms in case of closed windows.

Figure 6 presents the probability distribution of measurement of the *difference of levels* $\Delta L_{A,out\text{-}in,road}$ for all the examined rooms in case of untight windows.

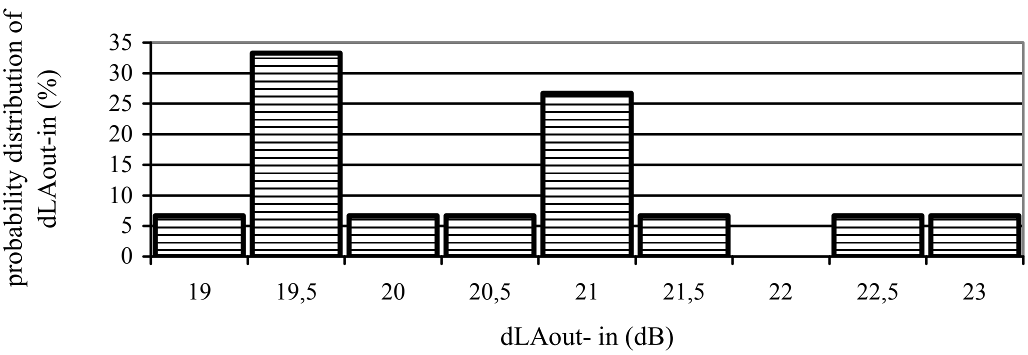


Figure 6. The probability distribution of measurement of *the difference of levels* $\Delta L_{A,out\text{-}in,road}$ for all examined rooms in case of untight windows.

Figure 7 presents the probability distribution of measurement of the *difference of levels* $\Delta L_{A,out\text{-}in,road}$ for all the examined rooms in case of half-open windows.

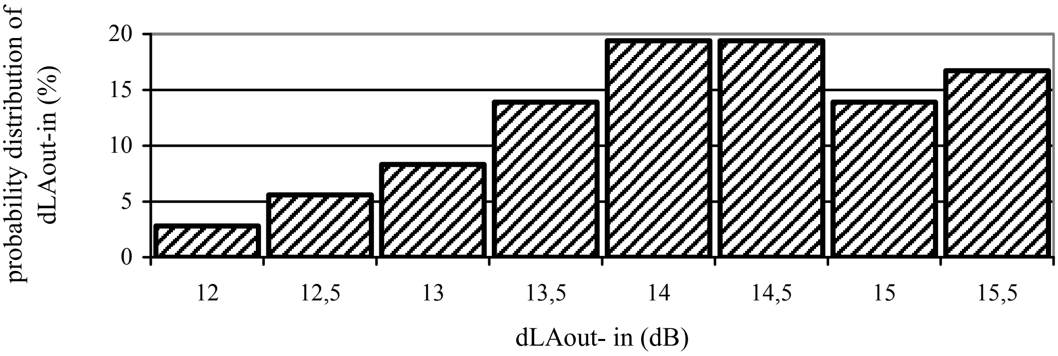


Figure 7. The probability distribution of measurement of *the difference of levels* $\Delta L_{A,out\text{-}in,road}$ for all examined rooms in case of half-open windows.

Figure 8 presents the probability distribution of measurement of the *difference of levels* $\Delta L_{A,out\text{-}in,road}$ for all the examined rooms in case of open windows.

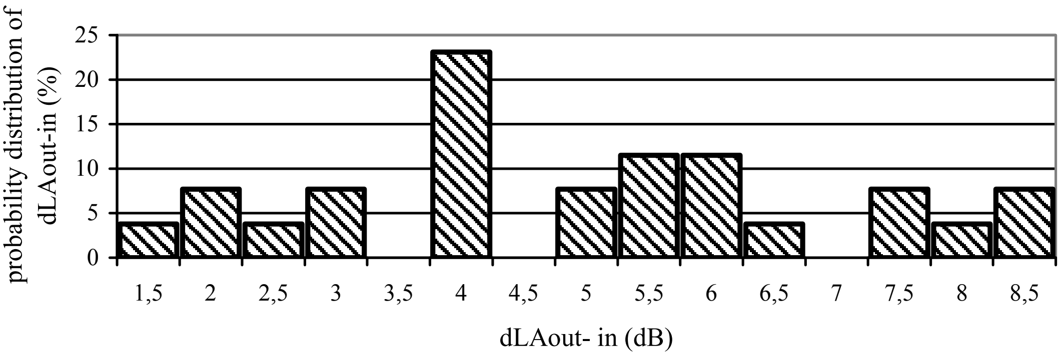


Figure 8. The probability distribution of measurement of the *difference of levels* $\Delta L_{A,out\text{-}in,road}$ for all examined rooms in case of open windows.

It results from figures 4 - 7 that *the difference of levels* $\Delta L_{A,out\text{-}in,road}$ for all the examined rooms (defined by the difference of sound pressure levels outside and inside the building) amounts to:

- 32.0 dB for closed windows (standard deviation of measurements results of particular rooms of 1.2 dB) and results from the area as well as sound insulation of windows,
- 20.3 dB for untight windows (standard deviation of 1.5 dB) and results from the area, sound insulation of windows and the size of the opening of the window,
- 14.0 dB for half-open windows(standard deviation of 1.1 dB) and results from the area and the size of the opening of the window,
- 4.8 dB for open windows (standard deviation of 2.2 dB) and results from the size of the opening of the window.

The results of measurements prove that in the case of noise prediction at office workstations, road traffic noise should be taken into account when the windows in the room are not closed (untight, half-open or open) during the majority of working time. It can be assumed in the estimated prognosis of road traffic noise at a workstation in a building that A-weighted sound pressure level will be smaller than the one determined outside the building by about:

- 20 dB for untight windows,
- 14 dB for half-open windows,
- 5 dB for open windows.

In order to estimate the number of office rooms in which the windows are not tightly closed, a number of random examinations was carried out – the position of window was checked in 1296 office rooms located in the vicinity of streets with high traffic intensity (about 4000 vehicles per hour, including 6% of heavy vehicles). The examinations were carried out several times in the first days of spring with 8-15^{o}C outside temperature. The averaged results are presented on figure 9.

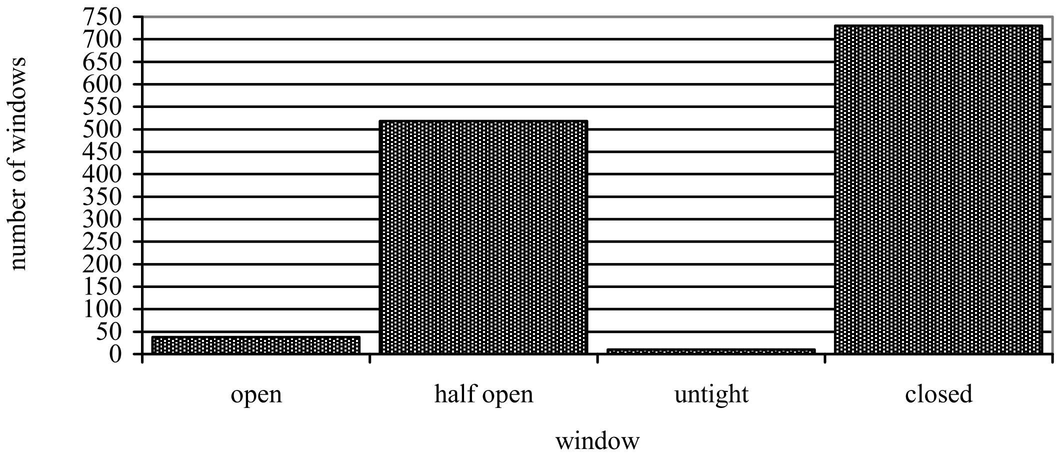


Figure 9. Average number of closed, untight, half-open and open windows in typical work conditions in 1296 office rooms.

In 43% of the observed rooms the windows were open or half-open and in these cases the outside noise (coming mainly from cars) should be taken into account as an important element of resulting noise at office workstations.

4. CONCLUSIONS

Road traffic noise at office workstations where natural ventilation is used should be taken into consideration in summertime (the results of measurements have shown than in about 40 % of office rooms windows are open or half-open).

The difference of A-weighted sound pressure levels between noise outside and inside the building $\Delta L_{A,out-in,road}$ for road traffic noise depends on the insulation of wall components (windows, massive part of the wall) only when the windows are closed or untight. When the windows are half-open or open, it depends only on the size of the opening between the window and the frame.

It can be assumed in the estimated prognosis of road traffic noise at a workstation in a building that A-weighted sound pressure level will be smaller than outside the building by 21 dB for untight windows (windows of acoustic insulation of more than 30 dB), 14 dB for half-open windows and 5 dB for open windows.

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REFERENCES

[1] W. Mikulski, "Hałas na stanowiskach pracy w budynkach biurowych - wielkości do oceny hałasu drogowego", *Proceedings of the XXXIV Zimowa Szkoła Zwalczania Zagrożeń Wibroakustycznych,* Ustroń Poland, 28.02-03.03.2006, pages 265-273 (2006).
[2] W. Mikulski, "Used results of assessments road traffic noise in surroundings to estimate road traffic noise at workplaces in the office buildings", *Proceedings of the 13th Congress on Sound and Vibration (*ICSV 13), 3-6.12.2006, Honolulu, USA,
[3] J. Nurzyński, "Empirical study on the sound insulation of simple slot ventilators", *Journal of Building acoustics,* vol **13**, no **3**, 2006, edited by Multi-Science Publishing CO. LTD., United Kingdom.
[4] J. Sadowski, *Podstawy akustyki urbanistyczne*, edited by *Arkady* Warsaw 1982, Poland