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Research of Different Noise Barriers Efficiency at Different Temperature

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Abstract. In this article was analyzed acoustic efficiency of two different construction noise barriers. Field measurements of noise tests were carried out before and behind a wooden barrier, which height was 2.9 meters and a wooden wall with equipped roof, which height was 3.2 m. As is known the length of the wall, height, surface roughness, shape and material of the wall – key aspects of determining the effectiveness of noise barrier. Different materials, depending on their characteristics of the hard or soft, porous or dense, interact differently with the sound of waves. Article contains research results of noise measurements at positive and negative air temperature. There analyzing wooden noise barrier acoustic efficiency at different temperatures and the effects of temperature to the diffraction of sound waves through the peak of the barrier. Test results show, that noise barrier without structural changes reduced noise level to 14–22 dB, noise barrier with structural changes reduced noise level to 20–23,1 dB, when air temperature was positive. When air temperature was negative, noise barrier without structural changes reduced noise level to 15,5–21,4 dB, noise level with structural changes to 19–26,6 dB.

Keywords: Efficiency, noise barrier, temperature, noise level.

Conference topic: Environmental protection.

Introduction

Road, rail transport, construction machinery, land agricultural machineries are the main source of noise. Noise is often referred to as undesirable sound (Monsefi *et al.* 2011). Road traffic is one of the most common sources of noise pollution affecting residents' quality of life, especially in an urban context (Kang 2006; Den Boer, Schroten 2007). It is considered that transport noise is one of the largest urbanization problems related to quality of life and health. In many cities the noise average annual increase in 1–3 dBA ("Community noise"), so it is often used additional noise insulation measures – greenery, screens, embankments, barriers.

For reduction of road and rail transport noise most commonly used noise barriers to enclosure roads and rail transport highways (Baltrėnas *et al.* 2007). The correct use of noise barriers is determined by design, economic, structural parts durability aspects. Many studies have been done with the aim to determine the noise level change at noise barrier zone. Noise barrier protects receiver from direct sound waves by reducing noise level in the zone of acoustic shadow. It should be noted, that noise barriers can not completely stop the sound waves, they only reduce the noise level of the screen in the territory. Noise reaches the receiver in other indirect ways, mainly due to the sound wave diffraction at the peak of the barrier (Monazzam, Lam 2008).

There are many different ways to increase the noise barrier efficiency: to increase the height of the barrier, using absorbing or reflective materials, change the form of the barrier (Monazzam *et al.* 2011). Making the geometric noise barrier changes take into account the height of the wall and construction costs (Monazzam, Fard 2011). According to the studies carried out and developed methods have been established as the noise barrier design changes at the peak of the barrier leads to a higher noise reduction (Baulac *et al.* 2008; Greiner *et al.* 2010). To improve the acoustic performance of noise barrier, construction is designed in various forms: T, Y, round, cylinder etc. (Cianfrini *et al.* 2007). Reviewing of the studies carried out to determine what form of acoustic wall is the most effective, most scientists came to the conclusion that the T-shaped wall of the absorbing surface is significantly more effective than the straight (Duhamel 2006; Naderzadeh *et al.* 2011). Noise barriers acoustic properties also depend on the materials from which it was made. Variety of design solutions can be used for installation of noise barriers. Noise barriers can be made of concrete, steel, glass, ceramic, plastic, wood. However, the changing temperatures may change materials acoustic properties because materials can soften, harden or crack due to temperature differencies.

The aim of this article- to establish, how noise barrier design changes results an acoustic performance at different ambient temperatures.

Methodology

Noise levels were estimated by measuring the noise level before the noise barrier and beyond at the selected points. Before the noise level measurements meteorological weather conditions was determined: air humidity, temperature and wind speed. The measurements were performed by using a precision sound level analyzer Brüel & Kjær 2270 (Fig. 1).

Fig. 1. Precision sound level analyzer Brüel & Kjær 2270

Field measurements were performed 1.5 meters before the barrier and beyond it at a height of 2.0 meters, when a person stands 0.5 meters from the device. Measuring time at a measuring point – 5 minutes. In order to compare different design noise barriers made from the same material, the noise level measurements were taken at points no. 1, no. 2 and no. 3, 2.0 meters above the ground were processes of the sound wave diffraction occurs (Fig. 2).

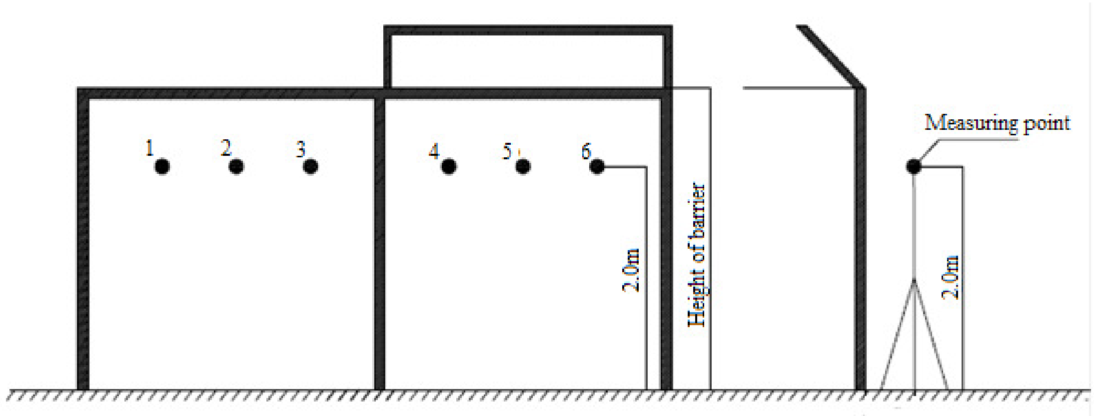

Fig. 2. Scheme of measurements at selected points

Different noise barrier construction causes different barrier dimensions: the wooden barrier height was 2.9 meters and a wooden wall with roof – 3.2 meters. Analyzing results, noise level reduction was compared in low, medium and high frequency range. All measurements are made at peak hours (12–14 h.). Noise barrier was fitted near to highway where traffic is relatively equivalent. That allows more efficiently and objectively evaluate noise barrier acoustic properties and noise propagation through them. To assess the environmental impact to properties of acoustic materials, field measurements were carried out depending on the season. Noise level reduction of the barriers set in different weather conditions. Noise level was measured at ambient temperatures between + 6 °C to 9 °C, and from – 6 °C to – 9 °C. Aim of this article to investigate the moisture, snow cover on the floor surfaces, wind speed and temperature impact for sound wave propagation and acoustic properties of materials.

Results and discussion

In figure 3 presented noise level measurement results at negative (b) and positive (a) temperature when analyzed noise barrier without a roof installed at the apex of the barrier in frequency range to 31.5 to 250 Hz. Test results show, that better noise reduction was at negative ambient temperature to (4–18 dB) evenly over the whole frequency range. Low-frequency noise s at positive temperatures better reduced with increasing frequency from 80 Hz. The noise level of the wall decreases from 1 to 11.5 dB.

In examining propagation of sound waves in the low frequency range (31.5 to 250 Hz) was found lowest difference between different constructions of noise barriers efficiency. Better noise level reduction observed, when noise barrier was equipped with a roof, but the difference is not large (0.3–3dB). Barrier, with structure changes, efficiency increases with increasing the frequency range. Noise level of 125–250 Hz frequency was reduced to 2–5.7 dB more than the barrier without a roof. Results presented at figure 4.

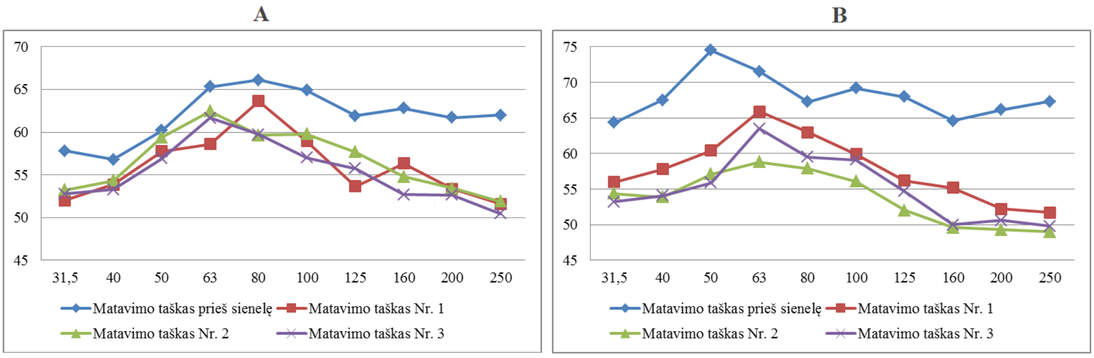

Fig. 3. Noise level results in front of and behind noise barrier without structure change at low frequency range: a – positive temperature; b – negative temperature.

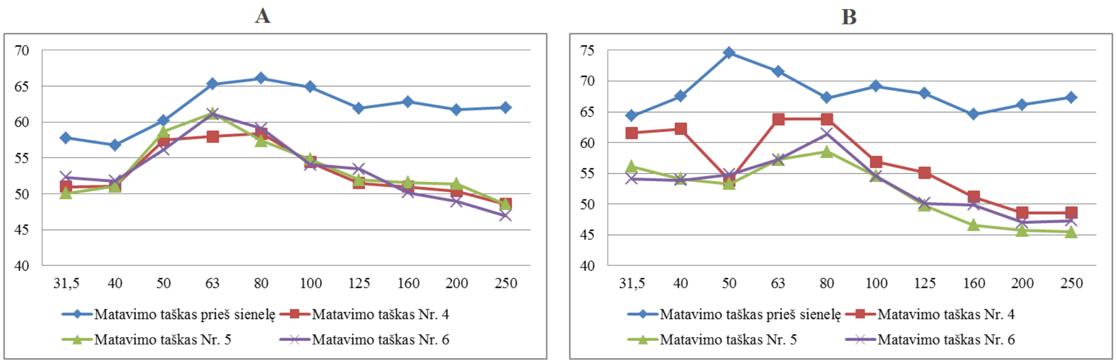

Fig. 4. Noise level results in front of and behind noise barrier with structure change at low frequency range: a – positive temperature; b – negative temperature.

Test results show, that in all frequency bands when barrier was with the roof and without it, better noise reduction was when the air temperature was negative. Noise level reduced 2–7 dB more than air temperature was positive. In examining propagation of sound waves in the low frequency range (31.5 to 250 Hz), the noise level reduced from 4.2 to 18.3 dB in construction without changes and to 2–17.4 dB when the roof was installed. The lowest noise level difference between different construction of noise barrier was noticed at 31.5 to 80 Hz. With increasing frequency to 250 Hz better noise level reduced, when the noise barrier was equipped with a roof. Barrier with equipped roof reduced noise level 1–4,6 dB more, than barrier without roof. Greater difference between different noise barrier construction was noticed at 315–1000 Hz, because sound waves absorbed better and the noise level was reduced more then frequency range increases. Figure 5 shows, that the construction without installed roof reduced noise level from 9.6 to 15 dB at positive ambient temperature and when temperature falls below zero noise level reduced more (14 to 17.5 dB).

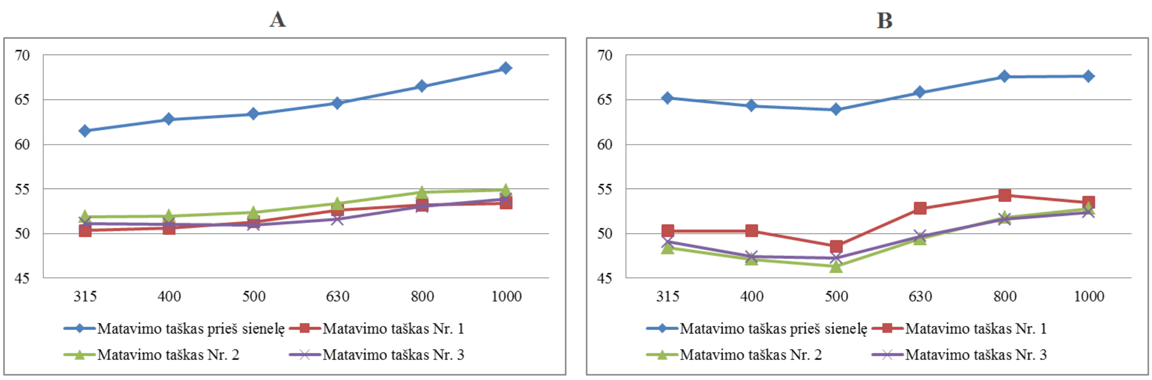

Fig. 5. Noise level results in front of and behind noise barrier without structure change at medium frequency range: a – positive temperature; b – negative temperature.

Figure 6 represents the measurement results of the tests carried out at the noise barrier with design equipped roof with a 45 ° angle at different environmental conditions. The noise level reduced from 12 to 19.5 dB at positive ambient temperature and 15.8 dB–20.4 at negative ambient temperatures. As low-frequency waves, 315–1000 Hz frequency wave more effectively reduced by noise barrier when temperature dropped below zero.

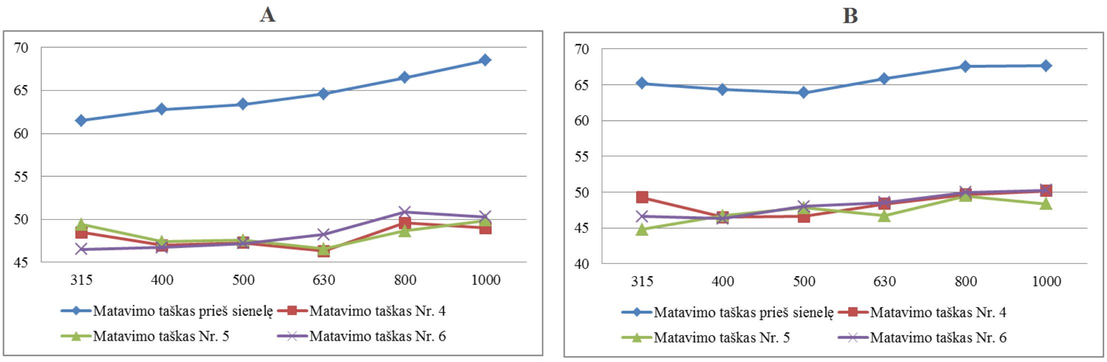

Fig. 6. Noise level results in front of and behind noise barrier with structure change at medium frequency range: a – positive temperature; b – negative temperature.

As shown in 5 and 6 figures, barrier, which had installed roof medium-frequency noise level reduced from 2 to 5 dB more when barrier, which was without installed roof. Measured different structures noise barriers acoustic properties was noticed that maximum noise level reduction was observed at more high frequency from 1000 to 8000 Hz. Figures 7 and 8 show, that when the air temperature is above zero noise barrier without structural changes reduced noise level to 14–22 dB and then the roof was installed on the top of the barrier noise level was reduced 4–8 dB more. When temperature was negative, noise barrier without roof rduced noise level- from 15.5 dB to 21.4 dB ad then roof was equipped noise level decreased from 19 dB to 26.6 dB with increasing frequency.

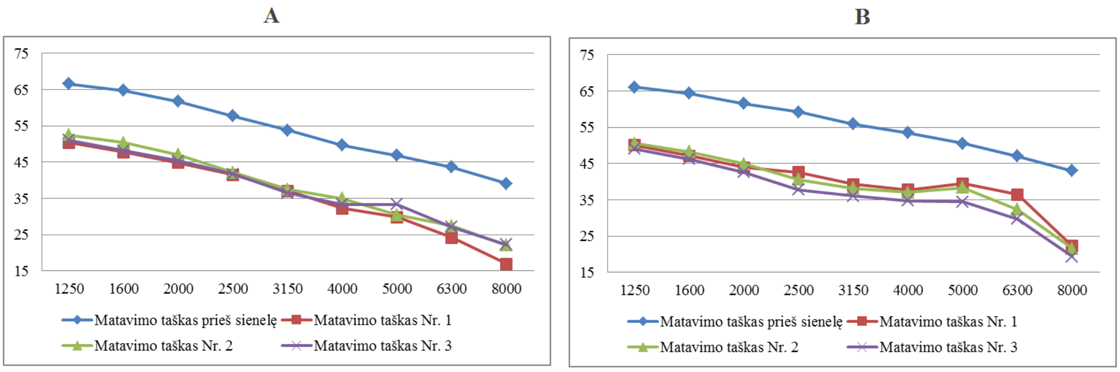

Fig. 7. Noise level results in front of and behind noise barrier without structure change at high frequency range: a – positive temperature; b – negative temperature.

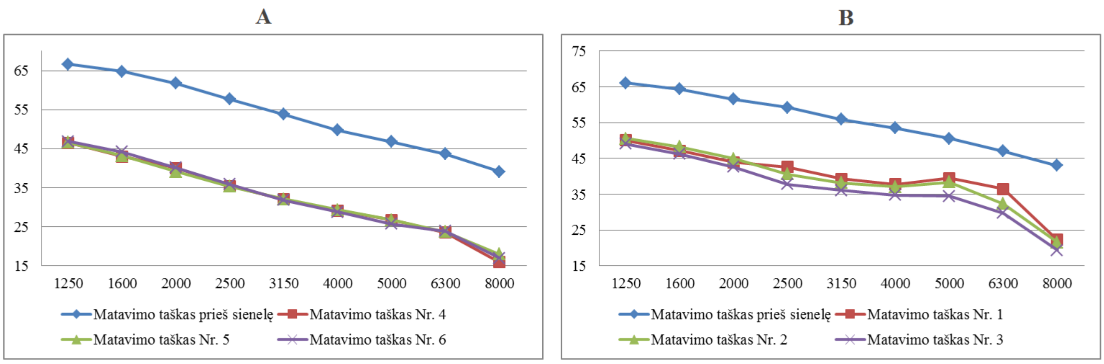

Fig. 8. Noise level results in front of and behind noise barrier with structure change at high frequency range: a – positive temperature; b – negative temperature.

In view of the low-frequency wave propagation was noticed that when air temperature was negative best noise level reduction was at the measurement point no. 2 and no. 5. Sound waves diffraction increases at edge points of measurement, where barrier construction was fixed. The same conclusion can not be claimed when the air temperature is above zero, because noise level reduction in different points was very unevenly. Therefore, at temperatures above zero was noticed that low-frequency wave diffraction processes, where barrier construction was fixed did not have a significant impact. Comparing the results obtained in the medium and high frequency range was noticed that in all measurement points at different weather conditions noise level was reduced evenly. It can be said that barrier construction fixing points not affected medium and high frequency wave and sound waves propagate uniformly along the barrier at the same height.

Conclusions

1. The noise measurement tests at different ambient temperatures show, that the weather conditions affect the propagation of sound waves through the acoustic barrier and sound wave diffraction processes.
2. It was found, that low frequency noise was least reduced by noise barrier. Noise reduction at 31,5–250 Hz frequency was 0,8–11,5 dB at points No.1–No.3. Construction with equipped roof reduced noise to 1,5–13,4 dB at points No.4–No.6. According test results, when temperature was below zero noise barrier efficiency was better, noise at measurement points No.1–No.3. was reduced to 4,3–18,3 dB, at points No.4–No.6 to 2,7–21,8 dB.
3. At medium frequency (315–1000Hz) noise level was reduced to 9,6–15 dB by noise barrier without roof. At measurement point of noise barrier with equipped roof noise level was reduced to 12–19,5 dB when temperature was positive. At low and medium frequency when ambient temperature was below zero, noise barrier with roof efficiency was lower than at positive temperature. Medium frequency noise was reduced to 14–17,5 dB at measurement points No.1–No.3. and to 15,8–20,4 dB at points No.4–No.6.
4. Best efficiency of noise barriers properties was found at high frequency from 1000 Hz. It was found that noise level was reduced evenly at all measurement points at different weather conditions. When temperature was below zero, noise barrier without roof reduced noise level to 14–22 dB, noise barrier with roof reduced noise lever to 20–23,1 dB. At positive ambient temperature noise barrier without structural changes reduced noise level from 15,5 dB to 21,4 dB and noise barrier with equipped roof reduced noise level to 19–26,6 dB.

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