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THE EVALUATION OF THE EFFICIENCY OF THE L-SHAPED NOISE BARRIER WHILE WORKING WITH THE PROGRAMME CadnaA

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Abstract. Due to the diffraction of sound the idea to change the form of the barrier using various designs of the top edge of the barrier has become a very significant factor while increasing the acoustic effect of the barrier. Newly designed shapes of a barrier edge is a means helping to solve problems related to the construction of noise barriers, such as too high, inefficient barriers having no aesthetic appeal. Besides, models of a specially designed barrier edge might be adjusted to already constructed noise barriers to achieve greater efficiency. There are various barrier models: T-, Y-, U-, arrow, fork, and cylinder shaped barriers and so on. In this article the efficiency of the noise barrier is estimated using noise dispersion modelling programme CadnaA. A typical situation is being modelled: using a noise barrier with cantilever, calculations of noise levels are done shielding a linear source of noise. The impact of a barrier cantilever on noise dispersion behind the barrier depending on the direction and angle of its declination is being evaluated. While changing the direction of the cantilever declination („right“ or „left“), configurations of 90°, 130° and 160° angles were being modelled. In the noise suppression environment the features of noise dispersion appearing because of an obstacle, i.e., because of an impact of the noise barrier, are observed in vertical direction receding from the barrier in 1, 3, 6, 9 and 12 m distances, in 1-6 m height.

Keywords: Noise barrier, diffraction, top edge, numerical modelling, „CadnaA“, L – shaped noise barrier.

1. Introduction

There are various means for reducing environmental acoustic noise (Venckus and Grubliauskas 2010). Noise barriers are one of the most efficient tools for noise suppression in cities and villages reducing the level of noise in its propagation path (Baltrėnas *et. al.* 2007; Grubliauskas and Butkus 2009a).

Barriers are used in production facilities to protect work places and also in factory areas aiming at reducing the effect of the noise coming from an open source on administrative premises and on residential districts which are nearby (Grubliauskas and Butkus 2009b). Noise barriers are most popular applied tools for protection against intrusive traffic noise (Okubo *et. al.* 2010; Vaišis and Januševičius 2009).

It is worth mentioning that barriers cannot completely stop the noise waves, they just protect the receiver from the direct noise and reduce the noise level beyond the barrier in the acoustic shadow zone (Grubliauskas and Butkus 2009b). In this case, noise reaches the receiver through indirect ways usually through the top edge of a barrier due to diffraction (Monazzam and Lam 2004).

There are numerous ways to enhance the effectiveness of noise barriers: to increase their height, to use noise absorbing or reflecting materials, to change their shape (Monazzam and Nassiri 2009; Ishizuka and Okubo 2009). Nevertheless, the greatest concern is caused by geometrical evaluation of noise barriers considering the height and the price for construction (Monazzam and Fard 2010).

Aiming at enhancing acoustic efficiency, a lot of theoretic and experimental researches were conducted (Monazzam and Nassiri 2009). Numerous methods were introduced for the achievement of the efficiency of noise barriers while enlarging them in height and changing their shape (Duhamel 2006).

The idea to change the shape of noise barriers due to sound diffraction using various designs of the top edge of a barrier has become very significant in enhancing the effect of the acoustic barrier (Auerbach *et. al.* 2010). The new designs of the top edge of a barrier is a tool for solving problems related to the construction of noise barriers, such as too high, inefficient barriers having no aesthetic appeal. Besides, models of a specially designed barrier edge might be adjusted to already constructed noise barriers to achieve greater efficiency (Watson 2006). The models being studied are very various: T-, Y-, U-, arrow, fork, and cylinder shaped barriers and so on (Cianfrini *et. al.* 2007; Okubo and Yamamoto 2007).

Acoustic features of noise barriers of various models are being examined and construction methods are being improved through experiments and numerical modelling (Baltrėnas and Puzinas 2009). However, it is expensive to construct a barrier as a tool for reducing noise. The main reason for this is that the designed parameter models are not matched (Xintan and Shuiliang 2009).

The aim of this work is, while using the noise dispersion modelling programme CadnaA, to evaluate the efficiency of the L-shaped barrier changing the direction and angle of declination in respect of a barrier.

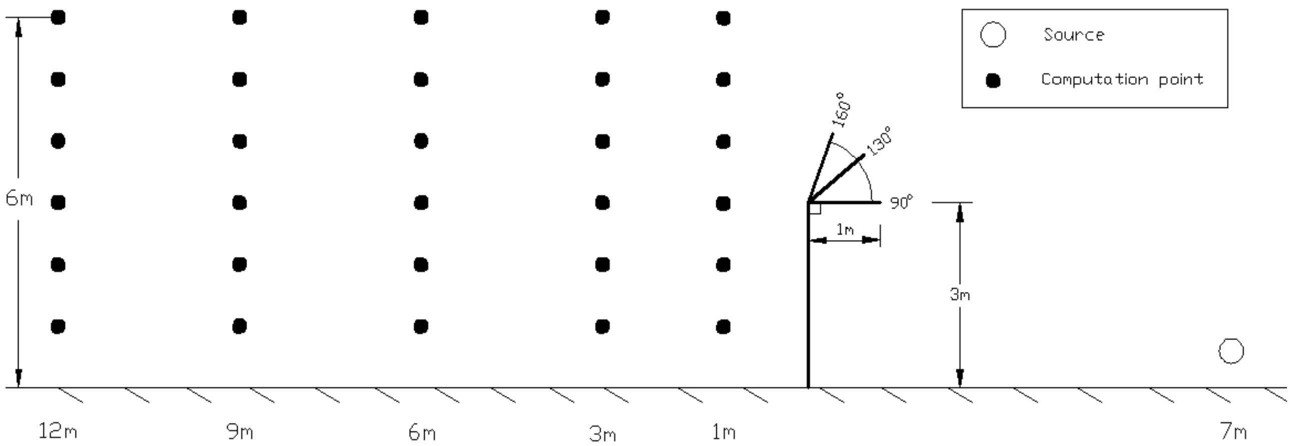
2. Modelling Methodology

The efficiency of a noise barrier is evaluated with the help of computer programme CadnaA performing noise dispersion modelling. A typical situation is modelled: using a noise barrier with cantilever, calculations of noise levels are done shielding a linear source of noise.

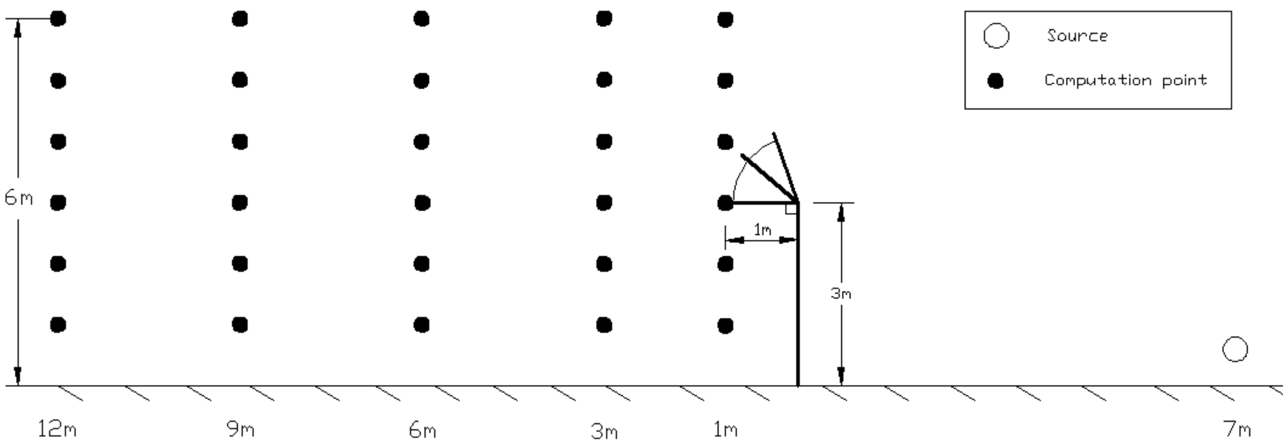
In order to do noise dispersion calculations, in the desktop of the programme CadnaA the borders of the area being modelled are delineated and the factors determining the level of the noise coming from the noise source are described.

The noise barrier is constructed 7 m away from the source of noise. The external dimensions of the barrier are measured: the length – 80 m, the height – 3 m. Acoustic performance parameters are determined, i.e., the capability of the barrier to reflect and to absorb sound is estimated, characterizing sound absorption coefficient is $\alpha = 0.84$ corresponding to the surface area of the right and left barrier. On the top of the barrier a cantilever is constructed. The length of the cantilever corresponds to the length of the barrier; its height – 1 m.

The calculations of noise dispersion are being carried out while changing the declination angle of the cantilever in respect of the barrier. Three declination positions are measured, respectively in 90°, 130° and 160° angles. The peculiarities of noise dispersion are analysed in such cases when the cantilever shifts towards the noise source (right) and towards the area where the reduction of the level of noise coming from the noise source is being observed (left) (1 a, b examples). Depending on the declination position of the element, the alternation of noise level is observed in the 12 m long, 6 m high, vertical plane behind the barrier as shown in 1 a, b picture.



a)



b)

Fig 1. The evaluation of the efficiency of the barrier while changing the declination angle of the cantilever: a) the declination positions towards the noise source; b) the declination positions towards the side of the noise suppression area

3. The Results of Modelling

The calculations of the alternation of noise levels were done using the noise dispersion modelling programme CadnaA when a linear noise source was shielded with a noise barrier. It was estimated how the cantilever fixed on the top edge of the barrier influences the sound dispersion behind the barrier depending on the direction and angle of its declination in respect of the barrier.

Changing the declination of the cantilever (right or left) the configurations of an angle of 90°, 130° and 160° were modelled. Each time the noise dispersion graphic image was created on the desktop of CadnaA programme. The noise dispersion is presented distinguishing the numerical values of the noise level in the points which are set in a vertical plane. In the area of noise suppression the peculiarities of noise dispersion due to the obstacle, i.e., due to the influence of the noise barrier, are observed in a vertical direction receding from the barrier in 1, 3, 6, 9 and 12 m distances in 1-6 m height (the distance among the observation points is 1 m).

Picture 2 presents a graphic image of the alternation of the numerical values of the levels of noise coming from the noise source. This was achieved while changing the declination of the cantilever towards the right, i.e., when the cantilever covers the noise source.

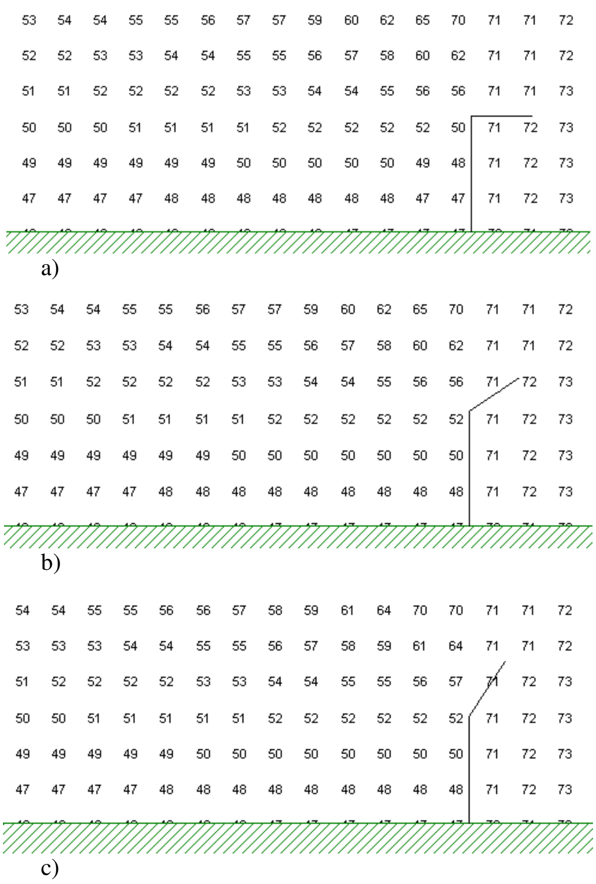


Fig 2. The sound dispersion while changing the declination of the cantilever towards the right, shielding the noise source: a) angle 90°, b) angle 130°, c) angle 160°

The outcomes presented in picture 2 show that the alternation of noise level during the propagation of sound waves through the barrier is very clear. The effect of the barrier to suppress the level of noise in the examined area at the height of the barrier where the greatest reduction in the noise level is observed reaches to 19–24 dB as compared with the noise level 1 m away from the barrier.

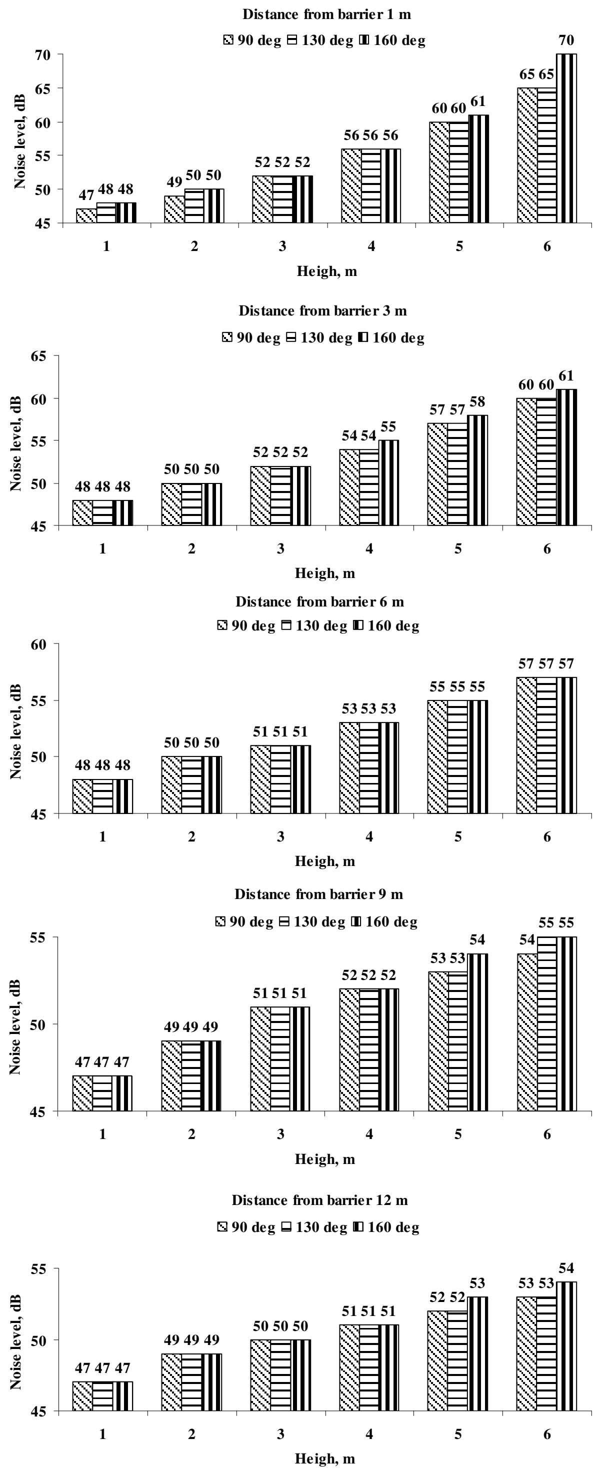


Fig 3. The alternation of the noise level at the observation points depending on the cantilever's declination angle towards the right

The results of the calculations on noise dispersion are introduced in picture 3 elaborating on the noise levels in observation points receding from the barrier and depending on the declination position of the cantilever.

From the data presented in picture 3 it becomes clear that the impact of the cantilever on sound dispersion 3 m height is observed only in one modelled occasion. The alternation of noise levels is different 1 m away from the barrier when the declination angle is 90°. This time in the points which are 1 and 2 m high the noise level was measured to be 1 dB lesser as compared to the cases when the declination angle was 130° and 160°. The regularity of the alternation of the noise level receding from the barrier in 3 m height is analogous; the suppression of noise receding from the barrier is observed.

While analysing the peculiarities of noise dispersion in higher layers of the examined area (4–5 m high), using 130° and 160° declination positions we get unprofitable suppression of noise coming from a noise source. It was measured that at 6 m height and at 1 m distance the noise level is higher even by 5 dB when the cantilever is set in 160° angle. Receding from the barrier 3, 9, 12 m away noise levels are greater by 1 dB. Having 6 m distance from the barrier the results of the calculations coincide throughout all examined cases.

Picture 4 shows the graphic image of the alternation of numeric values of levels of noise coming from the noise source changing the declination position of the cantilever in 90°, 130°, 160° angle towards the left.

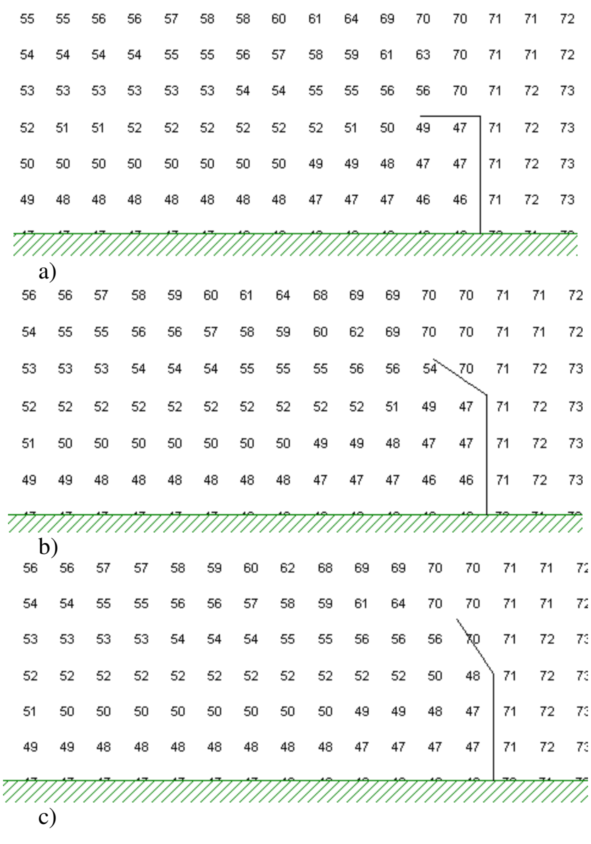


Fig 4. The sound dispersion while changing the declination position of the cantilever towards the left: a) angle 90°, b) angle 130°, c) angle 160°

In this case the effect of the barrier to suppress the noise level in the analysed area at the height of the barrier depending on the declination of the cantilever changes from 19 to 25 dB as compared to the noise level in the shielded area 1 m away from the barrier.

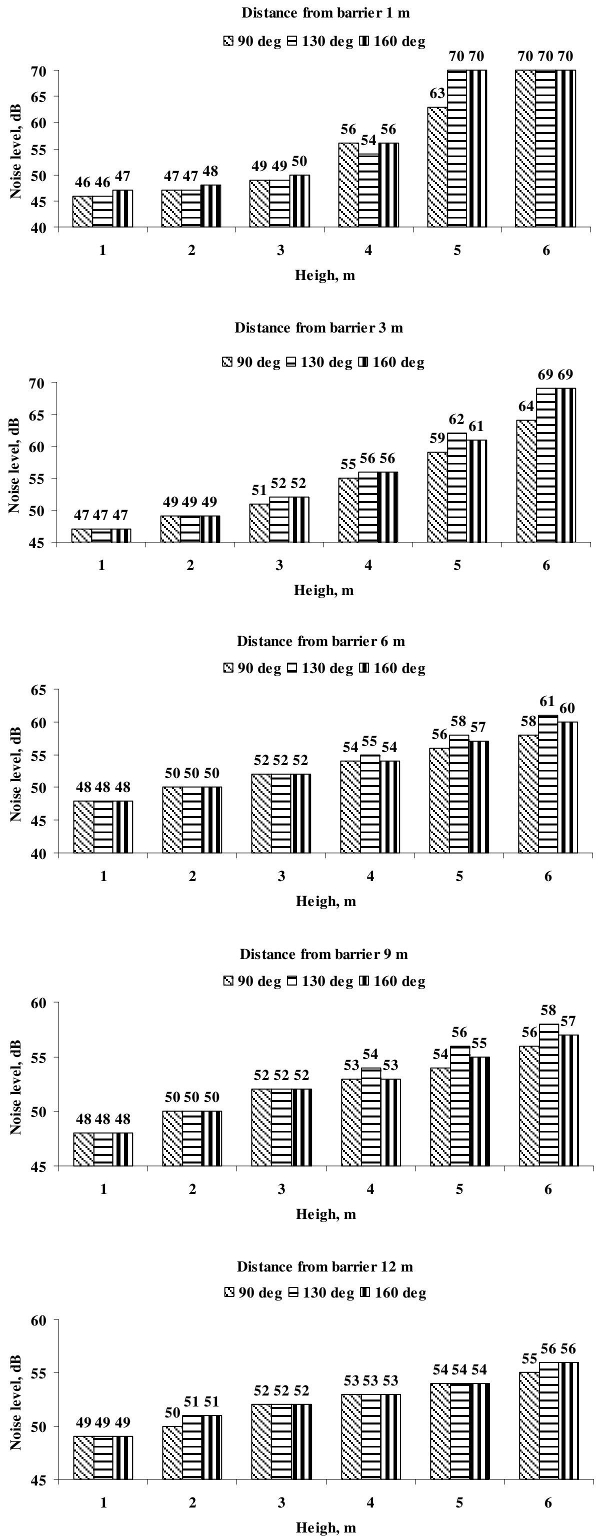


Fig 5. The alternation of the noise level at the observation points depending on the cantilever's declination angle towards the left

In picture 5, except for the numerical values of noise level in observation points, depending on the declination position of the cantilever, the greatest reduction of noise level is observed 3 m high in the zone which is 3 m away from the barrier.

While analyzing how the cantilever declination influences the alternation of noise dispersion at the height of the barrier, it appears that the optimal declination of the cantilever for suppressing noise in the entire analyzed area is 90°. Cases when the cantilever is inclined in the angle of 130° and 160° 3 m high is less efficient in reducing noise level in 1 and 3 m distance from the barrier.

While evaluating how the position of the cantilever impacts the dispersion of noise 4–5 m high at the observation points 3, 6, 9 and 12 m away from the barrier, the greatest effect of noise suppression was obtained when the cantilever was set in the angle of 90°. When the cantilever was in the angles of 130° and 160°, the 2 dB superiority was observed only in one measuring point: 4 m high and 1 m away from the barrier. The greatest noise levels in higher layers of analyzed area were noticed when the cantilever was set in the angle of 130°.

While changing the cantilever's declination position towards the right or left, it appears that the regularity of sound level alternation behind the barrier changes depending on the declination direction of the cantilever. When the cantilever is turned towards the right in the suppressed noise zone behind the barrier the suppression of noise level is observed in the entire 12 m long, 6 m high area of noise dispersion. In that case, when the cantilever is turned towards the left behind the barrier there appears a 3 m long, 3 m high zone of suppressed noise where the greatest reduction of the noise level is observed.

4. Conclusions

1. The most suitable declination position towards the right or left for suppressing the level of noise in the entire area being analysed is 90°. The estimated noise levels depending on the height and distance from the barrier are 1–7 dB smaller.
2. The most unprofitable suppression of noise coming from a noise source (towards the right or left) at 130° and 160° declination positions are observed at the highest layers of the area being analysed, 4–5 m high.
3. While changing the declination position of the cantilever towards the right in the analyzed 12 m long and 6 m high area, the reduction of the noise level receding from the barrier is observed.
4. In the case when the cantilever is turned towards the left, the biggest reduction of the noise level behind the barrier is being observed in the 3 m long and 3 m high zone of suppressed noise.

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