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IMPLEMENTATION OF NOISE BARRIERS AS AN EFFECTIVE ACOUSTIC SOLUTION IN ROAD TRANSPORT

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Abstract: The rising noise levels represent one of the major environmental issues of today. This increase is noticeable not only in residential and industrial areas but especially in the vicinity of heavily trafficked road and railway routes. The main source of external noise is traffic. Effective noise protection requires comprehensive and high–quality solutions included in the design documentation, such as a noise study that is specific to the location. However, the adverse acoustic impacts on the population can be effectively mitigated through appropriate urban planning and the implementation of noise control measures such as acoustic barriers and screens. In addition to their primary function of providing noise protection, these elements also contribute to shaping the character and aesthetics of the environment in which they are integrated. The construction of noise barriers is one of the measures to comply with the permitted noise level limits. The extent and parameters of these barriers are determined on the basis of calculations and analyses carried out as part of the noise study. The design documentation must meet the criteria for noise protection, therefore it is important to design solutions based on data from the noise study. The main output of a noise study is a noise map, which shows the effects of noise in a given environment using isophones.
Keywords: noise protection, acoustic impacts, road traffic, environmental problems

1. INTRODUCTION

One of the current problems in the field of environmental protection is the increasing noise. [2] Noise negatively affects the human body, affects its activities and overall health. This problem occurs not only in residential and industrial locations, but especially in the vicinity of road and railway communications. [6] Negative sound impacts on people can be mitigated by appropriately designing noise protection measures such as noise barriers. [22] In addition to the main function of environmental protection, noise barriers also have a secondary effect on the formation of the space in which they are located. [22] Noise barriers (Figure 1) also include noise walls (Figure 2). [8]

Figure 1. Low noise barrier BRENS BARRIER in Prague–Hlubočepy [11]

Figure 2. Noise barrier [13]

The main source of external noise is traffic. Effective noise protection requires comprehensive and high–quality solutions included in the design documentation, such as a noise study that is specific to the location. [15] The design documentation must meet the criteria for noise protection, therefore it is important to design solutions based on data from the noise study. The main output of a noise study is a noise map, which shows the effects of noise in a given environment using isophones. [6] The construction of noise barriers is one of the measures to comply with the

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permitted noise level limits. [4] The extent and parameters of these barriers are determined on the basis of calculations and analyses carried out as part of the noise study. [22]

2. EVALUATION OF NOISE EXPOSURE LEVEL FROM ROAD TRANSPORT

Objectification of road traffic noise in accordance with legislation

The evaluation of the level of noise load in the protected environment around roadways is carried out by comparing the measured or calculated values of noise quantities for various situations and reference time intervals with the permissible values of these quantities, which are established in accordance with the legal regulation that deals with the objectification and evaluation of noise, infrasound and vibrations in the external and internal environment. [17]

Criteria for the design and implementation of noise control measures

The decisive criterion for the design and implementation of noise control measures in the vicinity of the monitored road is the exceeding of the permissible value of the determining quantity for individual reference time intervals, caused by traffic on the relevant section of the monitored road. If, for the relevant time interval and the monitored territory or location, the difference between the total sound level value (equivalent A–weighted sound level) and the value of the determining quantity for road traffic noise (equivalent A–weighted sound level) determined by measurement or prediction for the monitored section of the road is [9, 17]:

— noise less than 3 dB, caused by traffic on the monitored section of the road affects the acoustic situation in the assessed location, or area significantly, traffic on the monitored road section determines the noise pollution in its affected surroundings, by implementing appropriate noise control measures it is possible to achieve a significant reduction in noise pollution in the monitored area,
— noise in the interval from 3,1 dB to 10 dB, caused by traffic on the monitored road section affects the acoustic situation in the evaluated location or area, the implementation of noise control measures in the vicinity of the monitored road will affect the noise pollution in its affected surroundings,
— noise in the interval from 10,1 to 19,5 dB, caused by traffic on the monitored road section affects the acoustic situation in the evaluated location or area minimally, the implementation of noise control measures in the vicinity of the monitored road will reduce the noise pollution in its affected surroundings minimally,
— noise greater than 19,6 dB, caused by traffic on the monitored road section affects the noise pollution in the evaluated location or area, the implementation of noise control measures in the vicinity of the monitored road section will not affect the noise pollution in the affected area.

3. DESIGN AND STRUCTURE OF NOISE CONTROL MEASURES

In order to protect the environment from road traffic noise, it is necessary to include conceptual solutions for noise abatement measures in road planning and documentation. [14] The reason for proposing these measures is the exceeding of the permissible values determining the noise level in a given protected external area. [5] This exceeding can be determined by direct measurements of traffic noise or by means of calculation methods.

The proposed noise abatement measures must meet acoustic and non–acoustic requirements [16, 18]. The level of detail of the noise abatement design is adapted to the level of PD. [6]

The principle of the solution for the noise abatement measure in the affected vicinity of the monitored road depends on several factors.

When choosing the principle of solving noise protection measures in an affected protected area where noise pollution needs to be reduced, the following is taken into account [21]:

— the size of the monitored area,
— the way the area is used (recreation, leisure, housing, healthcare, work),
— the number of residents living in this area,

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— the size of the buildings in which they live (single–storey, multi–storey),
— the spatial arrangement of buildings (single buildings, a group of buildings, a residential area),
— the design of the buildings that need to be protected from noise,
— the configuration of the surroundings of the monitored road in the area,
— the current and expected intensity and composition of traffic on the monitored road,
— the position of the buildings that need to be protected in relation to the monitored road,
— from previous assessments and noise assessments in accordance with the text, if such assessments are available.

The proposal of measures is made in several variants. The proposed variants can be from the same group or from different groups, or their combination.

The selection of the final solution variant is made by assessing several proposals. The decisive criterion is the fulfillment of the permissible values of the determining quantity for the given category of protected area and the reference time interval [19]. Additional criteria for the selection of a suitable variant are construction and technical conditions and possibilities, economic and aesthetic aspects, acceptance of the proposed solution by the inhabitants of the affected area and others.

From the perspective of the principle of solving the reduction of noise pollution from road transport, noise control measures can be categorized as follows [12]:

— transport–organizational,
— construction–technical,
— urban–architectural,
— urban–transport.

Individual measures can be combined with each other.

4. LOCATION OF THE NOISE WALL

The effect of a noise barrier by screening is most effective if it is placed as close as possible to the road. If the design cannot be implemented by the road due to terrain obstacles, the wall can also be placed near the recipient if it is located in an isolated group of houses. [20] The suitability of this solution needs to be checked with regard to the ownership relations of the area where the noise barrier will be implemented. [7]

The rule that the noise barrier should be placed as close as possible to the source or recipient does not apply if the road is in a cut or if they are separated by a terrain elevation. In this case, it is best to place the noise barrier at the top of the slope or cut. [12]

The noise load on the recipient side is most influenced by the traffic flow furthest from the noise barrier. Simply increasing the height will not change the dominant influence of the noise caused on the recipient side by the furthest traffic flow. Raising the noise barrier to eliminate this effect can lead to unacceptably high walls. In such situations, it may be advantageous to use a second noise barrier, located between the traffic lanes, because the two walls are located as close as possible to the two noise sources – see Figure 3.

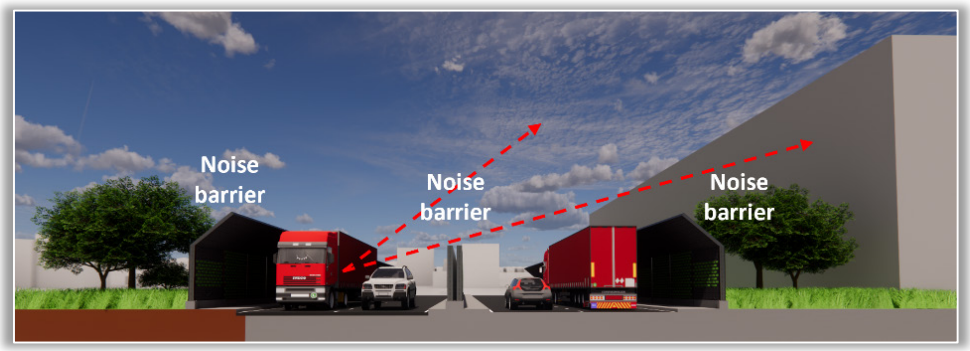

Figure 3. The applied noise barrier between two conveyor belts to improve shielding

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This technique allows the overall height of the noise barrier to be minimized and is particularly beneficial for [12]:

- roads, highways, with a median strip,
- situations where the recipients are located above the road level.

The length of the noise barrier

The dispersion of sound does not only occur at the top of the sound barrier, but also at its ends. Therefore, the overall noise reduction of a noise barrier depends not only on its height and location between the noise source and the receiver, but also on its length (Figure 4).

The sound that is scattered at the ends of the sound barrier is less important than the sound that is scattered at the top edge, because this transition path will still be favored by the absorption effect of the terrain. If there is enough space and it is necessary to reduce the noise load in a smaller area or even in a limited space, the length of the noise barrier can be reduced by bending its ends away from the road (Figure 4).

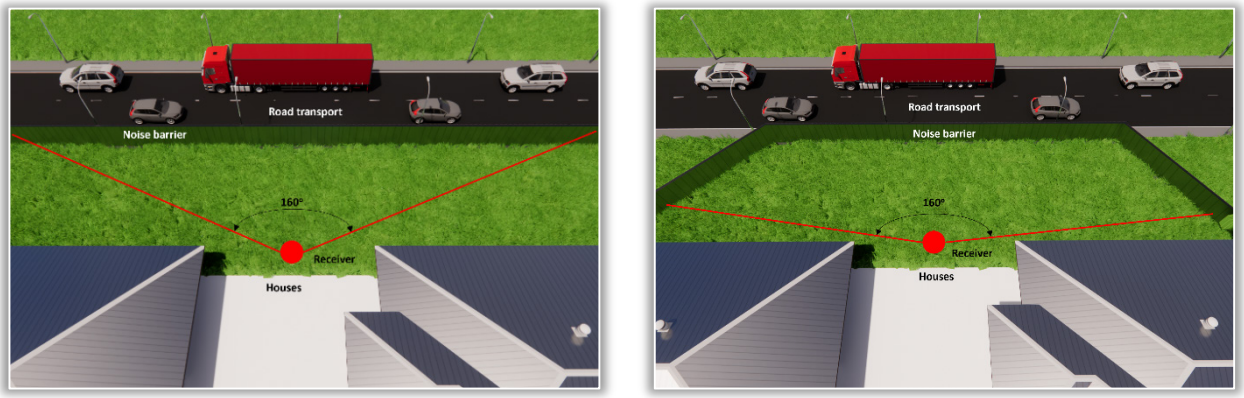

Figure 4. Reducing the length of the noise barrier by bending the ends away from the road

Properties of materials

Noise generally travels in all directions (Figure 5). Effective noise protection requires comprehensive and high–quality consideration in the design documentation, specifically in a noise study that is specific to the area. [10] The design documentation must meet the noise protection criteria, and it is therefore important that the design solution is based on the analysis of the noise study. The result of the noise study is a noise map that graphically depicts the noise distribution in the area using isophones. [12]

One measure to comply with permitted noise level limits is the construction of noise barriers. [3] The extent and parameters of these barriers result from noise study calculations.

In general, the materials [1] from which noise barriers are made are divided into two basic groups [12]:

- noise–reflecting – they do not transmit sound, but reflect it into space (often preferred in areas outside residential zones),
- noise–absorbing – the material absorbs sound (these materials are used most often in urban areas). The most popular are sandwich panels with sound insulation.

Reflective noise barriers

With a reflective wall, there is a reflection of noise and its further spread into space. Reflected noise is noise originating from an imaginary source, located at the same distance from the wall as the source, but on the opposite side of the communication. [12]

Even if the imaginary source is located further from the receiver than the real source, it must be taken into account and the need for shielding the imaginary noise source must be verified. In the case of tall vehicles, noise reflections occur between the objects of the vehicles and the adjacent wall, and the acoustic properties of the wall can reduce them.

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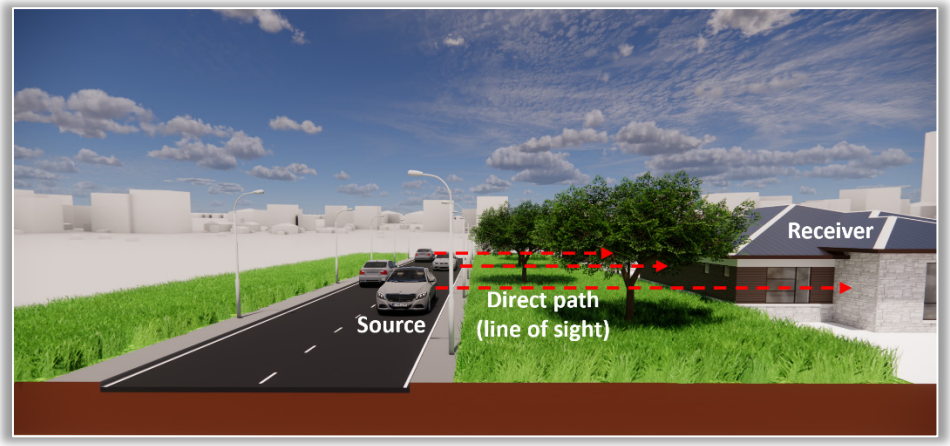

Figure 5. Direction of propagation of sound waves without a reflective noise barrier

The reduction in the acoustic properties of a reflective wall when any vehicle passes along it significantly affects the increase in peak noise levels (the distance between the vehicle and the wall is not decisive), to which the equivalent noise level L_{Aeq} is sensitive. The restoration of the acoustic properties of the wall is achieved by using a noise–absorbing layer, even if the vehicle object is higher than the wall. [12]

Figures 6 to 8 illustrate the direction of sound wave propagation using reflective noise barriers.

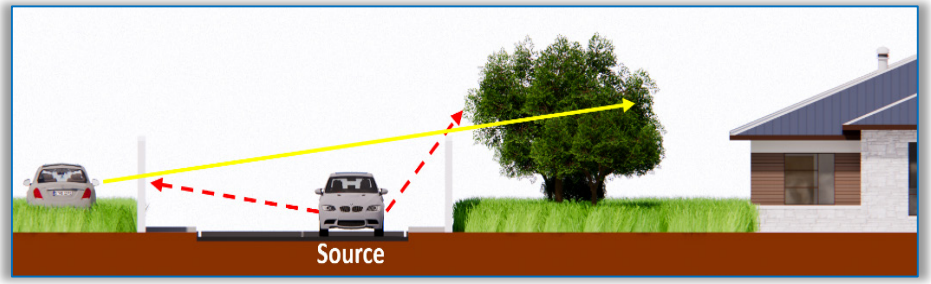

Figure 6. Direction of sound wave propagation using a reflective noise barrier

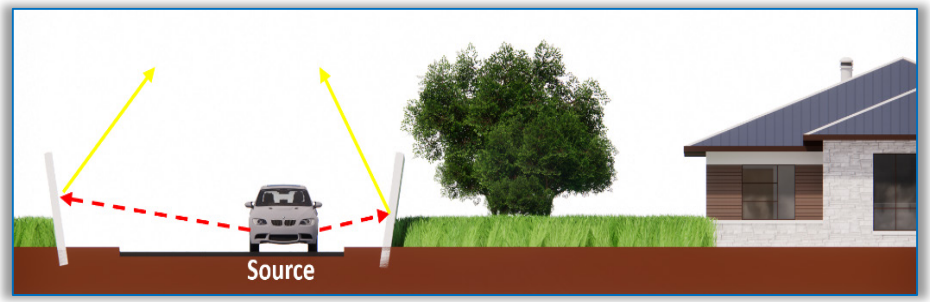

Figure 7. Direction of sound wave propagation using a reflective noise barrier

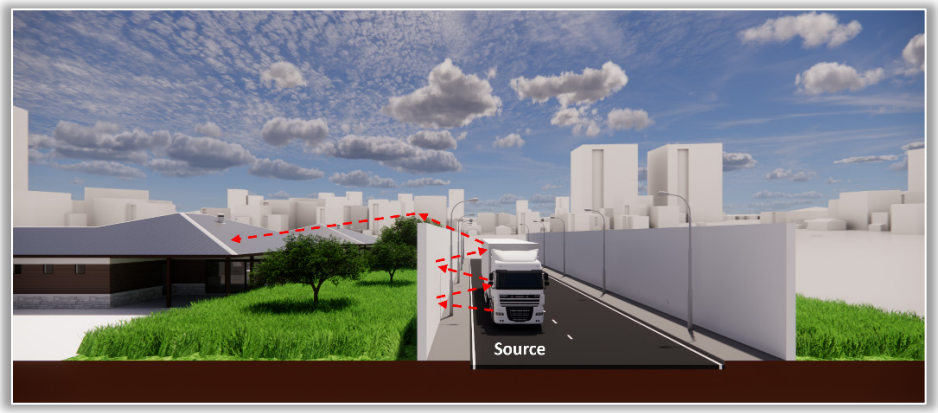

Figure 8. Multiple reflections between the noise barrier and the truck

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Barriers with absorptive treatment

The current trend is to use soundproof walls with an absorptive finish (Figure 9) to the greatest extent possible, which absorbs sound as close as possible to the noise source. Especially in cities, it is required to minimize noise, rather than reflect it further into space.

There are two main groups of sound absorption mechanisms used in sound absorbing walls. Most sound absorbing walls have a permeable layer of material that faces the incident sound. The flow resistance of the porous material causes the acoustic energy of the sound waves to dissipate within the material and eventually transform into thermal energy. We are talking about sandwich folded infill panels.

The mechanism of the second group is based on the Helmholtz resonator principle, when the incident sound wave enters a series of cavities in the wall through small holes or narrow openings, where it is absorbed. The most powerful absorbing materials, such as mineral wool, are protected and enclosed in a casing (case) whose surface exposed to the sound is perforated. These casings can be made of wood, steel, aluminum, ceramic, or recycled plastic. [12]

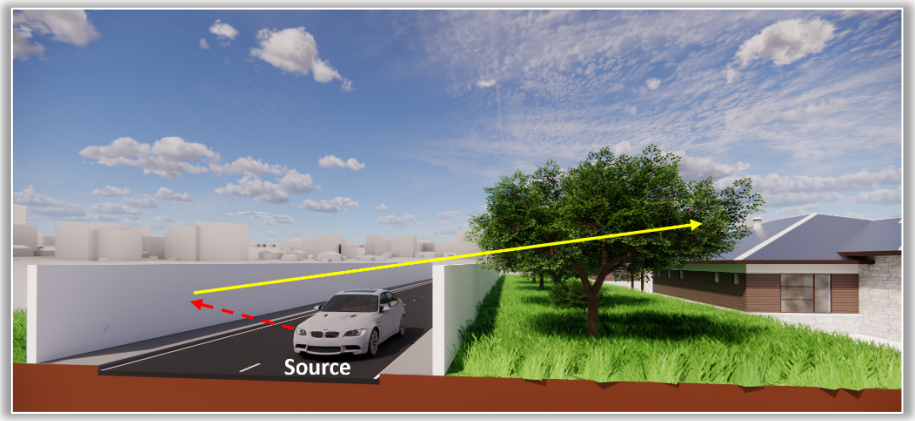

Figure 9. Direction of propagation of sound reflected from a noise barrier with absorbing material

Figures 3 to 9 were created in the modeling program SketchUp and then rendered in the Enscape 3D program.

5. CONCLUSION

From the article on noise barriers, it is clear that these structures have significant potential to mitigate the negative impacts of noise in the environment. Their effectiveness in protecting residents from traffic and industrial noise is irreplaceable. However, their effectiveness depends on proper design and implementation, as well as a comprehensive solution that takes into account local conditions and needs. Therefore, it is essential that the design and implementation of noise barriers are based on a thorough analysis and assessment of the environment and meet the highest standards of quality and safety. With the right approach and care, noise barriers can create an environment where life is more pleasant and healthier for all its inhabitants.

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