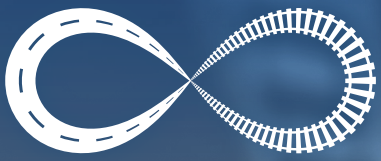

CETRA 2018

5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

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PERCEPTION OF TRAFFIC NOISE AND PROTECTION MEASURES BY PEOPLE LIVING ALONG THE ROAD

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Cracow University of Technology, Poland

Abstract

Traffic noise is a widespread problem with regard to residential building. The problem becomes highly relevant for properties located near busy roads. Residents of such places often lack the opportunity to rest in peace and quiet on their properties. The paper presents compiled methodology of empirical and simulation studies conducted with the aim of ergonomic formation of a building surroundings. Some selected properties situated near primary roads in peri-urban areas of Krakow were analysed. Usability of noise maps was analysed in terms of simulation modelling of noise propagation within a property in search for the areas suitable for rest zones. There is an attempt to find methods for shaping such area, considering privacy and mental comfort that are critical for relax and rest. An indicator of the ergonomic land use in that approach will be, among others, the level of noise in the area given in relation to the whole property located near the road. The analyses show that the shaping of land use enables rest and leisure also on the properties adjacent to noisy roads. That method may be used to check the efficiency of additional screen (noise barriers, greenery and fencing)

Keywords: traffic noise, barriers and screens, road

1 Introduction

Many people own building plots of land situated in the vicinity of roads. Others, either tempted by promises of a comfortable and easy access by car or by an attractive price, acquire plots of land in the vicinity of busy national or provincial roads on the outskirts of cities or outside city limits, without recognising the current or future nuisance related to traffic and noise in particular. Meanwhile, it should be of high importance, at the stage of acquiring the premises or designing residential buildings, to pay careful attention to the location of the building on the plot of land, the arrangement of individual rooms, particularly those intended for rest and to the optimal shaping of the surrounding environment, taking into account the criterion of leisure. The criterion of noise should, without a doubt, be an important factor in designing a new building and in adapting acquired ones. It is crucial to create an optimal and healthy environment for living, learning, working or relaxing. One of the main features of the environment in the proximity of roads is the acoustic environment; the residents of premises situated by roads are often unable to rest at home. Therefore, when analysing e.g. the optimal place for living and in particular – for resting, one should not overlook the criterion of the acoustic environment where this rest is to take place. In addition to acoustic screens, there are many other ways to reduce the impact of traffic noise on the inhabitants' rest. This can be done at the stage of planning the development of a plot of land; it is then that one should look for the building's optimal location together with an access road and place for rest and recreation. One should also remember to take into account the distribution of rooms within the building and consider which rooms are more sensitive to noise and which are less. This

paper presents a method of analysing the location of a residential building and the area of leisure on its premises where noise levels are acceptable and conducive to rest. The method in question assumes the use of noise maps which were created with the help of noise simulation techniques together with the simulation empirical measurements of noise for verifying the calculations. The noise was also analysed at subsequent building façades, especially those with windows belonging to rooms intended for leisure.

2 Research methodology

The research methodology consisted in calculations of noise and its distribution with the use of the SoundPlan® software. Before the implementation of the relevant simulation analyses, a verification of a calculation model was carried out with the use of on-site examinations conducted for chosen test sites. Measurements of noise were carried out on sites located around the premises. Figure 1a presents an exemplary layout of verification points. Figure 1b shows a building chosen for verification situated by a road.

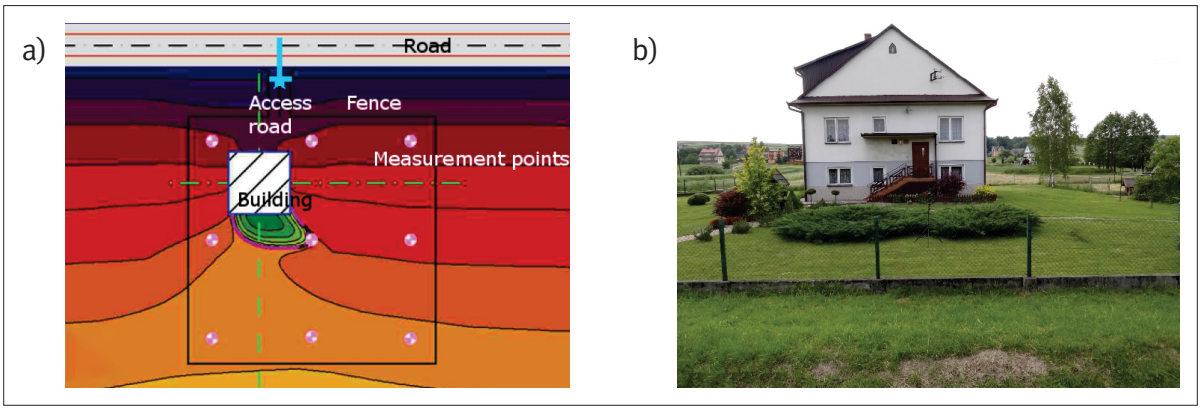

Figure 1 a) An exemplary layout of verification points in a calculation model; b) An example of a building located by a road, chosen for verification –without acoustic screens [own work]

The comparison of the results of empirical studies with the results of the noise forecasts for the projected on-site conditions and the measured traffic (intensity, share of heavy duty vehicles and speed) substantiated the use of the calculation model of the SoundPlan® software for further analysis. The average error for the tested measurement points was 1.5 dB. The analyses which were carried out for model solutions have been conducted for a plot of land measuring 40 x 40 m occupied by a single, two-storey, family house of 10 x 10 m and 8 metres high. The plot of land is situated in the middle of 1km-long section of the road. The analyses assumed traffic parameters of averaged values obtained from verification on-site measurements; i.e. the intensity of light vehicle traffic: 674 P/h, heavy vehicle traffic: 222 P/h, average speed for light vehicles: 65 km/h and for heavy ones: 64 km/h. The cross-section of the road consists of a roadway which is 7.0 m wide and lanes which are 3.5 m wide. All calculations were carried out for the height of 1.5 m. The analyses included: a change of the location of the building, the impact of the noise-reducing fence (2 m high), the effect of additional barriers located on the premises and the impact of the position of the access road on the propagation of noise on the plot.

3 The analysis of noise on the premises

The following figures show the analysis of the results of the simulation calculation of propagation of noise for six model locations of the building together with the access road and the fence within the premises. The reason behind this examination was to establish the location of the area with decreased noise. It is assumed that noise below 55dB is not likely to disturb recreation and leisure (4). The results are presented in the form of noise maps for analysed

cases. The traffic noise map, as a factor conditioning the shaping of leisure zones for premises adjacent to the road, will determine the area of the leisure zone (size, shape and location) available to residents. In this approach, the Authors ignored the upward distribution of noise which might be significant for the arrangement of rooms inside the building (for the storeys above the ground floor) as well as for the potential construction of a terrace. In the first variant, the building is located in the centre of the plot; the fence reducing noise is 2 m high (e.g. stone wall, brick wall, etc.).

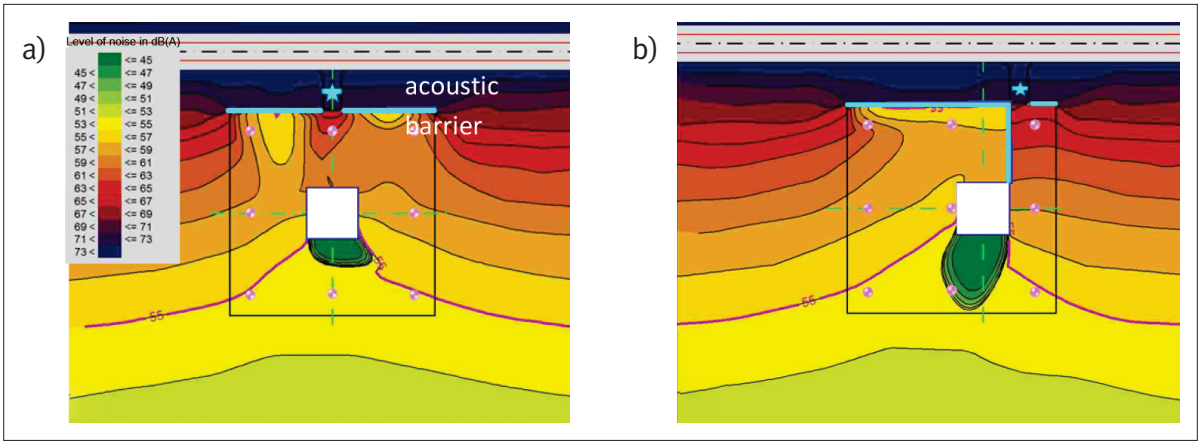

Figure 2 The propagation of noise on the premises: a) the and access road in the middle of the plot of land, the fencing facing the road partly shields the premises; b) the building and the access road are moved to the side of the plot of land, fencing off the road partially covers the premises; within the premises, parallel to the access road, there is a partition wall. [own work].

This solution enables the creation of a zone with reduced noise in accordance with the table shown in Figure 2a – the yellow and green colours are located behind the 55 dB contour line. The quietest façade in the presented arrangement is the one located on the side of the house facing away from the road. This knowledge allows for a rational layout of rooms in the building. Variant 2 assumes that the building is removed from the centre of the plot of land and the access road is located by the border of the premises. Along the plot of land there is also a noise-reducing fence with an opening for the access road. In addition to this, the section of the road within the premises is separated from the rest of the road by some form of barrier, e.g. a wooden noise-reducing fence. The use of such a solution results in the reduction of the level of noise reaching the building and an enlarged area of decreased noise.

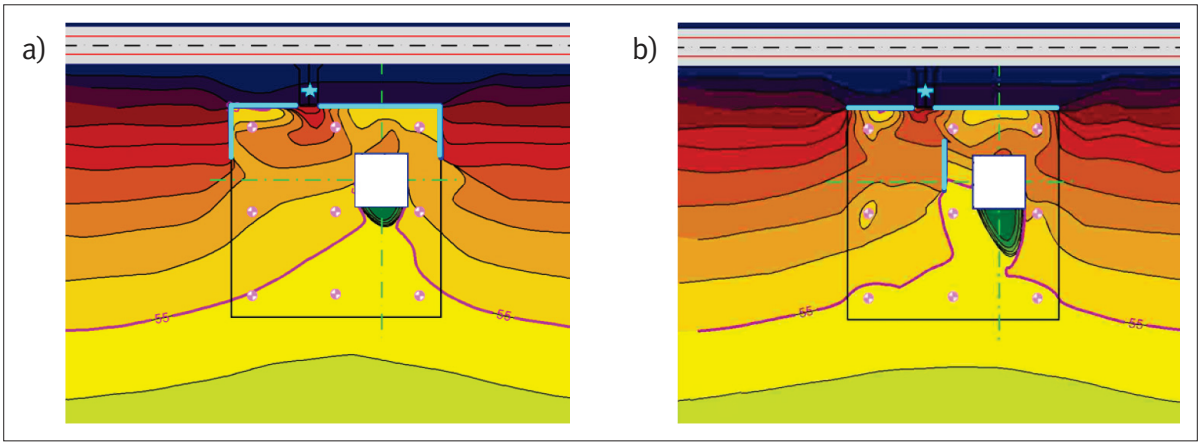

Figure 3 The propagation of noise on the premises: a) the building and access road are moved to the opposite sides of the plot of land, the fence facing the road was extended along the sides of the parcel; b) the building and the access road are moved to the opposite sides of the plot of land, the fence facing the road partially covers the premises, a partition wall was located parallel to the access road. [own work]

Figure 3a illustrates the layout of the premises with a new location of the access road in relation to the building in Figure 2b. In addition to this, the noise-reducing fence located along the sides of the plot was extended, which resulted in a change in the propagation of noise around the premises. The fourth variant (Figure 3b) assumes the situation presented in Figure 3a, but with an inner fence between the access road zone and the building. In this case, there is a noticeable decrease in noise at the front of the building and the area of decreased noise is enlarged. The remaining part of the site is not attractive in terms of acoustics. Instead of the fence, one can build here a garage with an access road or plant additional greenery.
Another solution, shown in Figure 4a, is a barrier, with the total length of 9 m and height of 4 m, located on the side of the building. No noise-reducing fences or additional barriers were implemented. The use of such a partition creates an area of approximately 20 sq m within which the noise level has been reduced. As the figure shows, the zone created by the barrier is directly adjacent to the area behind the house, thus creating a quiet space which can be utilised in a variety of ways. An area like that may accommodate a playing nook as well as a seating area for socialising and relaxation. The decrease in the noise level should be satisfying, considering the fact that the entrance doors and windows will be placed behind the screen, which should guarantee acoustic comfort in the building.

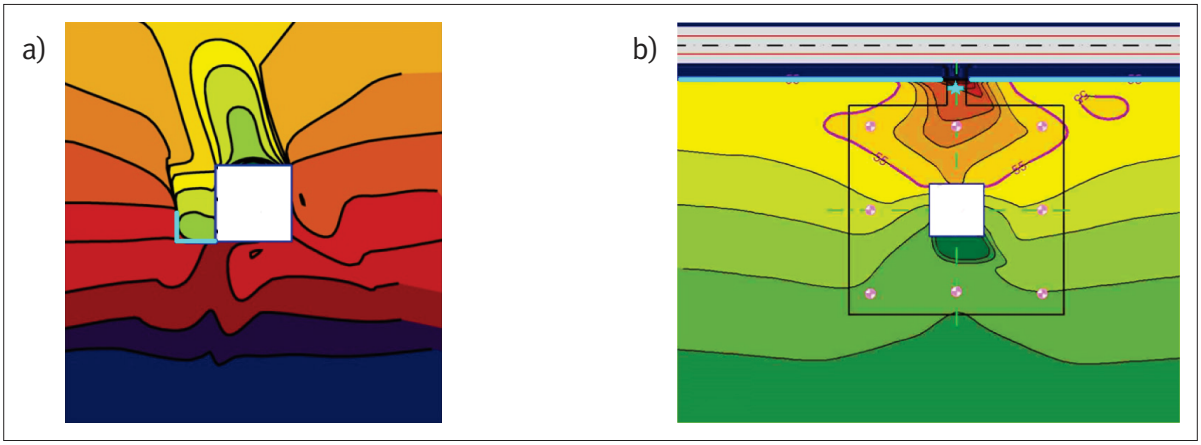

Figure 4 The propagation of noise on the premises: a) no acoustic barriers by a fence, an L-shaped partition placed inside, by the building; b) an acoustic screen was located along the road with an opening for the access road [own work]

The knowledge of propagation of noise is an important factor shaping the leisure zone, both for existing acoustic screens and for planned ones. To demonstrate this fact, Figure 4b presents the propagation of noise within the premises with the building situated in the centre and the access road (with an opening in the screen) in front of the building. The solution presented in Figure 4b features a visibly enlarged zone of decreased noise, below 55 dB. However, in this case also its shape should be taken into consideration when devising development plans for the plot of land. Additionally, it is evident that noise at higher levels reaches the façade facing the road. This information should be considered when planning the arrangement of rooms in the building. All the examples above show how important it is to analyse the planning stage of the premises development for creating an optimal rest area on the plot of land. Apart from the acoustic properties, other aspects of the rest zone are important. These include issues related to the aesthetics of the surroundings, as well as the privacy that many inhabitants seek. For this reason, additional greenery (mid-size and high, e.g. shrubs, trees, etc.) and elements of landscaping architecture are planned within the premises. When arranging this zone, it is important to plan the way in which one wishes to relax. Figure 5 presents an example of such an area located behind a residential building with an additional barrier consisting of thuja trees.

Figure 5 An example of a rest zone located behind the building shielded by a greenery [own work]

4 Survey of noise perception by the inhabitants of households surrounded by roads

The main objective of the survey was to examine the sensitivity of people living in the vicinity of roads to road noise, both before deciding on the purchase of a building plot and after moving in. The survey included residents for whom the house and its surroundings are the area for relaxation. The survey was accompanied by simultaneously conducted measurements of characteristics of the traffic and road noise. This allowed to draw a comparison of noise impact as perceived by people living in the vicinity of roads, as well as the impact of the operation of the road on the acoustic environment and conditions for relaxation.
The survey study was conducted in 19 localities in the Małopolska Voivodeship along national and provincial roads in the periods: September/October 2016 and May/June 2017. 75 households were included in the study. The content and form of the questions taking into account the time limit for interviews was established in two stages to obtain a full clarity of the survey as perceived by the locals. The study included questions related to the discomfort caused by road noise, and in particular its impact on the conditions of rest and difficulties with resting. The issues of survey questions aimed at investigating:

- the impact of road noise on residents of buildings in the vicinity of roads,
- noise assessments by the inhabitants,
- ways of solving the problem of noise nuisance by the use of different elements which may act as a barrier against noise,
- knowledge and awareness of the inhabitants concerning ways of counteracting noise nuisance at the planning stage and in the existing surroundings,
- location criteria taken into account by the respondents at the stage of purchasing real estate (home or/and the plot) and at the stage of planning the plot development, taking into account the criterion of environment ergonomics, recreation and the criterion of road noise,
- the knowledge and awareness of architects who design houses along roads, as well as informing investors into such homes about the hazards related to noise and the difficulties in organising one's leisure environment,
- rationales for the choice of location of the building on the plot and the particular rooms within the building, and the access road, etc.

An important aspect was the age of the building. A number of the survey questions were related to the stage of buying a property and planning of the plot, which in the case of "old" houses (not built by the current inhabitant, e.g. inherited or purchased) did not apply. The results of the survey have been developed statistically, separately for each of the questions,

also by referring them to the results of empirical research the spread of noise around the selected test sites representing different research models of development along the road. As one could have expected, the study confirmed the nuisance of noise, with 92 % of surveyed residents complaining about the levels of noise being too high. As many as 82 % of the inhabitants did not have any knowledge about the nuisance of noise at the acquired/inherited property before moving in. In the analysed cases, the main determining factors for buying real estate were: the location of the plot, its cost and access. Noise and leisure opportunities were not indicated among the location criteria (Fig. 6).

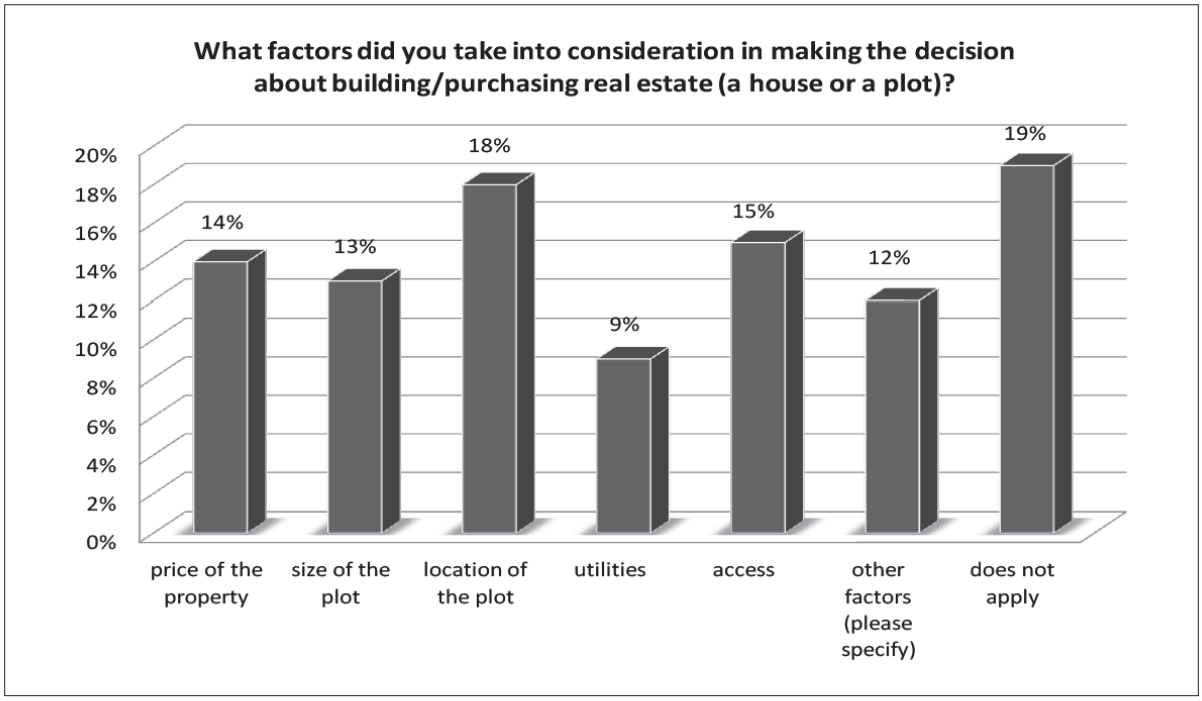

Figure 6 Selected results of the survey [own work]

An important problem is the arrangement of leisure within the grounds, as well as the rooms within the building, so as to limit the penetration of noise to the rooms and leisure areas. As is apparent from the responses of respondents, architects generally do not take into account the criterion of leisure ergonomics in their designs (61 %). Local residents only realised the importance of noise nuisance after moving in. The majority of respondents (69 %) implemented various sound protection measures on their properties, mainly barriers of greenery combined with the fence. The presented results represent only a small portion of the results of the survey and highlight the importance of deliberate shaping of the premises surroundings, and a change in perception in the assessment of noise nuisance when living close to roads and being exposed to high levels of noise every day.

5 Conclusions

The presented methodology of research conducted in order to achieve optimal shaping the environment of the building showed the usefulness of noise maps for simulation modelling of propagation of noise within the property to find an area to be used as the zone of leisure. What was also sought were the ways of shaping such a zone while taking into account privacy and mental comfort necessary for relaxation and rest. After having conducted the analyses of the model solutions, it can be concluded that it is possible, and in some cases necessary, to plan out zones with a lowered noise level at the property: such that is not disruptive to rest and recreation. Growing traffic will cause the noise to become more and more of a burden for the surrounding area. Not everywhere terrain conditions, such as the width of the road

lane, will allow for the construction of acoustic screens, or even if there are screens, the noise level may still be disruptive for local residents even though it will be lower than the maximum level. In Poland, for example, for areas with mixed-use development the level of acceptable sound in the daytime is 65 dB. Support should be given to the fight against noise carried out individually by the inhabitants of properties adjacent to the road. Of course, when it comes to newly emerging construction investments, the best solution is to prevent the location of the buildings in a zone of risk of significant traffic-related noise, but with buildings already existing internal shielding becomes a rational solution to the problem. Analyses have shown that conscious shaping of property development allows for rest and recreation also on grounds of properties adjacent to the noisy roads. This method can be used to measure the effectiveness of additional barriers (e.g. greenery, fences and screens).

The research was carried out within the framework of the project "Ochrona przed hałasem drogowym" ("Protection from road noise") financed by the National Centre for Research and Development and the General Directorate for National Roads and Motorways.

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