

Noise Impact on Inhabitants in Residential Areas under Various Anti-Noise Measures

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ABSTRACT: The sound environment is an inseparable part of the living environment. Noise is generally considered to be any sound or sounds which are undesirable, disturbing or harmful to people. Road transport has been the dominant source of noise in the environment for a number of years. Traffic noise modelling is used particularly for assessing the acoustic situation in the vicinity of roads, the identification of noise impact on population, designing anti-noise measures, strategic noise mapping, and action plans.

Regarding noise impact within the assessment of sustainable transport development, the programme SoundPLAN assessed different types of noise impact on inhabitants in residential areas through the use of alternatives such as the reduction of vehicle speed, construction of anti-noise barriers, installation of low-noise road surface, and various combinations of these. For the production of noise maps, input data was combined with geographic data or map materials respectively, data on buildings, roads, inhabitants, and traffic data.

The article presents the results of calculations of equivalent levels of acoustic pressure together with the division of impact on population into individual zones. Calculations are simulated on a terrain model of a part of the residential area surrounded by a busy trunk road and for the daytime. The residential area consists of detached houses and blocks of flats with a maximum height of 5 floors with the usual community amenities – garages, small shops, etc. Therefore, the application of simulated anti-noise measures may lead to a reduction of the negative impacts on the environment as well as on human health.

KEY WORDS: Anti-noise measures, road noise impact on inhabitants, SoundPLAN.

1 INTRODUCTION

On the topic of the noise impact within the assessment of sustainable transport development, the programme SoundPLAN assessed different types of noise impact on inhabitants in urban areas under such alternatives as the reduction of vehicle speed (Striegler et al., 2009), construction of anti-noise barriers, installation of low-noise road surface (Křivánek et al., 2012), and various combinations of these. For the production of noise maps, the input data was combined with geographic data or map materials respectively, data on buildings, roads, inhabitants, and traffic data.

2 CALCULATION SOFTWARE SOUNDPLAN

Traffic noise modelling is particularly used for: assessing the acoustic situation in the vicinity of roads, identification of noise impact on inhabitants, designing anti-noise measures, strategic noise mapping, and action plans.

The software is produced by Braunstein+Berndt GmbH; its use for acoustic calculation was approved by the National Reference Laboratory for communal noise at the Hygienic Station in Ústí nad Orlicí in July 1997. This software allows the modelling of the assessed area according to the current situation and the calculation of an isophone field in accordance with the given traffic technology (Braunstein+Berndt GmbH, 2008). After running the software, several modules of options are offered, see Figure 1.



Figure 1: SoundPLAN manager after opening.

2.1 Input data

- Geographic data or mapping materials:
 - topography and altimetry;
 - orthophotomap.
- Information about buildings:
 - position of buildings;
 - ground plan, height of buildings and number of floors.
- Data on roads:
 - routes of roads and railways;
 - road, railway profile;
 - type of road surface, rail track structure;
 - bridges, tunnels, etc.
- Data on inhabitants:
 - number of inhabitants in the monitored area is mentioned;
 - number of inhabitants per one address point, average number of inhabitants per one address point, etc.

- Data on industrial noise sources:
 - location and parameters of noise sources.
- Traffic data:
 - 24-hour traffic volume, train lengths, number of take-offs and landings of airplanes;
 - time division of traffic volumes into daytime (6 - 22 h) and night time (22 - 6 h);
 - composition of traffic flow – types of vehicles, trains, airplanes;
 - travel speeds in different road segments.

2.2 Output data

The output consists of data assessment providing summarizing overviews of the outdoor noise from road traffic and industry in a monitored area which can be used as material for the preparation of land-use planning documentation, or for informing the public on the condition of the environment. In compliance with the current legislation, the only binding descriptor to describe the condition of the acoustic situation in a certain area is the equivalent level of acoustic pressure A (L_{Aeq}) (Act no. 272/2011 Sb.; Act no. 258/2000 Sb.).

2.3 Noise modeling

The accuracy of the calculation results is particularly based on the accuracy and quality of the input data. It needs to be taken into account that any calculation software is just a powerful tool for the modelling of an acoustic situation. The accuracy of the calculation of noise maps is limited by the geographic accuracy of commonly available mapping materials and other input data (FEHRL, 2008). Regarding the digital mapping model ZABAGED 1 : 10 000, the root mean square error (root mean square error not the maximum deviation) for points clearly identifiable in terrain (railways, roads, buildings, etc.) is estimated at approx. 5 m. The impact of other changes of basic input parameters of calculations on emission values L_{Aeq} is shown in Table 1 (Ládyš et al., 2006).

In order for the calculation method or the software product used for the calculation of noise in an area to be acceptable, the calculations need to show the results in the same accuracy level as can be attained through field measurements (Methodological guidance of the measurement and evaluation of noise in an out-working environment, 2001). The difference of value L_{Aeq} from the conventionally correct value L_{Aeq} should not exceed 2 dB, i.e. the total uncertainty of the calculation model ± 2 dB. With the approved methodologies for calculations for individual types of noise it is possible to reach this value on the basis of a sufficient precision of the input data.

Table 1: Value of the next error of noise map calculation on the basis of inaccurate input data (Ládyš et al., 2006).

| Calculation input | Input change | Value change L_{Aeq} |
|--------------------------|-----------------------|------------------------|
| Traffic volume | $\pm 10\%$ | ± 0.4 dB |
| Traffic flow composition | $\pm 5\%$ NA | ± 0.5 dB |
| Traffic flow speed | $\pm 10\%$ | ± 0.8 dB |
| Road alignment | $\pm 1\%$ (both ways) | ± 0.3 dB |
| Surface type | Ac ($F3 = 1.1$) | ± 0.4 dB |

2.4 Alternatives of calculation of equivalent noise levels and impact on population

Calculations of equivalent noise levels, whose source is only road traffic in urban areas, and the impact on the population at a certain level of exposition, were performed for the following situations during the daytime:

Speed reduction alternative:

- 1A) Calculation of the “current situation” – all roads speed 50 km/h;
- 1B) Calculation of the “current situation” – trunk roads 50 km/h, urban roads speed 30 km/h;
- 1C) Calculation of the “current situation” without traffic on trunk road – speed 50 km/h;
- 1D) Calculation of the “current situation” without traffic on trunk road – speed 30 km/h.

Alternative with low-noise surface:

- 2A) Calculation of the “current situation” with installed low-noise surface on trunk road – all roads speed 50 km/h;
- 2B) Calculation of the “current situation” with installed low-noise surface on trunk road – trunk road 50 km/h, urban road 30 km/h;
- 2C) Calculation of the “current situation” with installed low-noise surface on all roads – all roads speed 50 km/h;
- 2D) Calculation of the “current situation” with installed low-noise surface on all roads without traffic on trunk road – speed 50 km/h.

Alternative with an anti-noise barrier (3 m height):

- 3A) Calculation of the “current situation” with an anti-noise barrier along trunk road – all roads speed 50 km/h;
- 3B) Calculation of the “current situation” with an anti-noise barrier along trunk road – trunk road 50 km/h, urban road speed 30 km/h.

To calculate noise maps and the overall noise impact on the population for the “current situation” in the model area in SoundPLAN software, the hourly traffic volumes during the day in accordance with Figure 2 were used. The calculation is simulated on a model area surrounded by a busy trunk road. The urban area consists of detached houses and blocks of flats with a maximum height of 5 floors with the usual community amenities – garages, small shops, etc. The assessment concerns just the noise from car traffic, no other impacts are considered (railway noise, industrial noise, household noise, etc.).

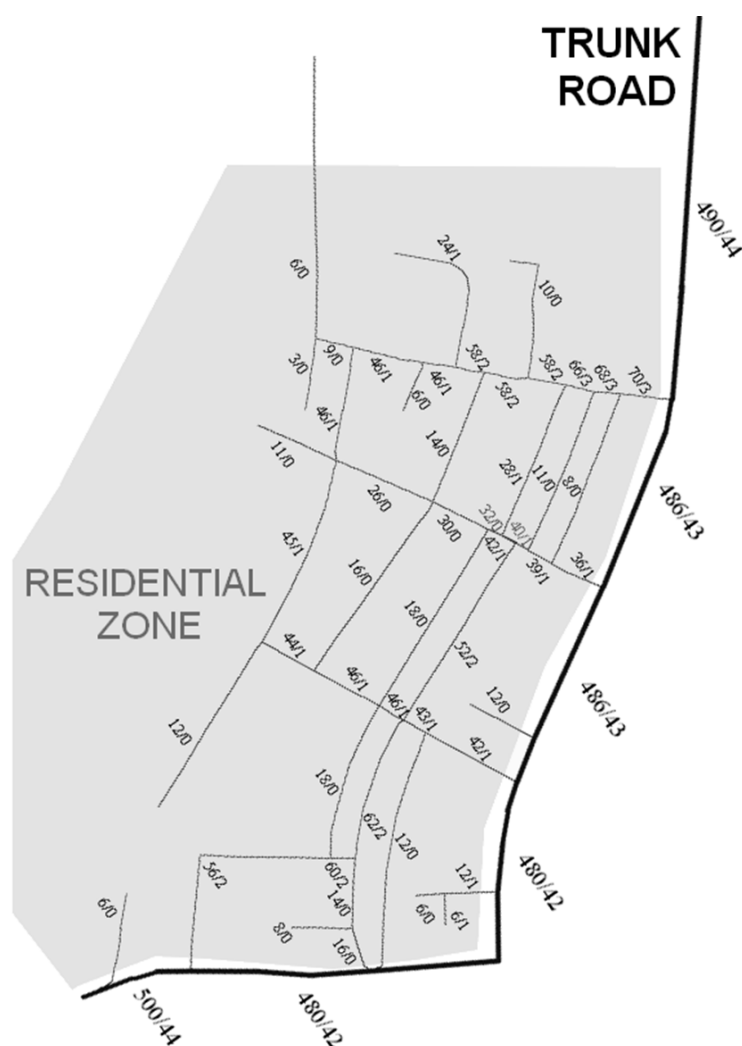


Figure 2: Hourly daily traffic volumes for the model area for the “current situation”.

3 CONCLUSION

Table 2 shows the number of inhabitants affected by noise in a given zone for individual model situations. The determination of the number of inhabitants affected by traffic noise in an individual two-decibel zone is then given by the cumulative data loading on the number of inhabitants affected by noise in all monitored entities (flats or houses). Subsequently, it is possible to assess the traffic noise impact and assess the designed anti-noise measures and their contribution to the reduction of impact of noise on the population.

The speed reduction from 50 km/h to 30 km/h in a residential area with a neighbouring busy road is unable to reduce noise levels in the most affected zone. Furthermore, the noise reduction through this measure in a residential area is not very effective due to synergic effects of the trunk road. With the low-noise road surface on the trunk road, it is possible to reduce the number of affected inhabitants in the most affected zone with a partial impact over the first line of the residential area. The low-noise road surface and the speed reduction from 50 km/h to 30 km/h on the trunk road in a residential area brings about a significant shift of the number of noise affected inhabitants to lower zone along its range, see Figure 3.

Table 2: Table of inhabitants affected by traffic noise in the model area for individual alternatives.

| Alternative | L_d [dB(A)] | below 42 | 42-43.9 | 44-45.9 | 46-47.9 | 48-49.9 | 50-51.9 | 52-53.9 | 54-55.9 | 56-57.9 | 58-59.9 | 60-61.9 | 62-63.9 | 64-65.9 | 66-67.9 | 68-69.9 | above 70 | Total |
|-------------|--------------------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|-------|
| V01A | No. of inhabitants | 29 | 12 | 469 | 188 | 521 | 581 | 621 | 538 | 423 | 510 | 353 | 399 | 933 | 345 | 3 | 2 | 5927 |
| V01B | No. of inhabitants | 36 | 223 | 351 | 368 | 505 | 530 | 470 | 500 | 473 | 439 | 350 | 399 | 933 | 345 | 3 | 2 | 5927 |
| V01C | No. of inhabitants | 1358 | 397 | 635 | 365 | 706 | 796 | 711 | 498 | 289 | 167 | 5 | 0 | 0 | 0 | 0 | 0 | 5927 |
| V01D | No. of inhabitants | 1392 | 615 | 502 | 512 | 605 | 674 | 759 | 477 | 254 | 135 | 2 | 0 | 0 | 0 | 0 | 0 | 5927 |
| V02A | No. of inhabitants | 29 | 31 | 450 | 191 | 530 | 710 | 588 | 623 | 798 | 554 | 681 | 563 | 174 | 5 | 0 | 0 | 5927 |
| V02B | No. of inhabitants | 36 | 253 | 321 | 371 | 528 | 621 | 473 | 586 | 846 | 472 | 678 | 563 | 174 | 5 | 0 | 0 | 5927 |
| V02C | No. of inhabitants | 122 | 488 | 331 | 554 | 838 | 545 | 186 | 585 | 489 | 373 | 674 | 563 | 174 | 5 | 0 | 0 | 5927 |
| V02D | No. of inhabitants | 2035 | 586 | 480 | 667 | 1101 | 516 | 199 | 305 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5927 |
| V03A | No. of inhabitants | 29 | 12 | 474 | 188 | 528 | 864 | 839 | 731 | 690 | 718 | 21 | 271 | 332 | 230 | 0 | 0 | 5927 |
| V03B | No. of inhabitants | 36 | 236 | 343 | 368 | 509 | 816 | 700 | 694 | 738 | 636 | 18 | 271 | 332 | 230 | 0 | 0 | 5927 |

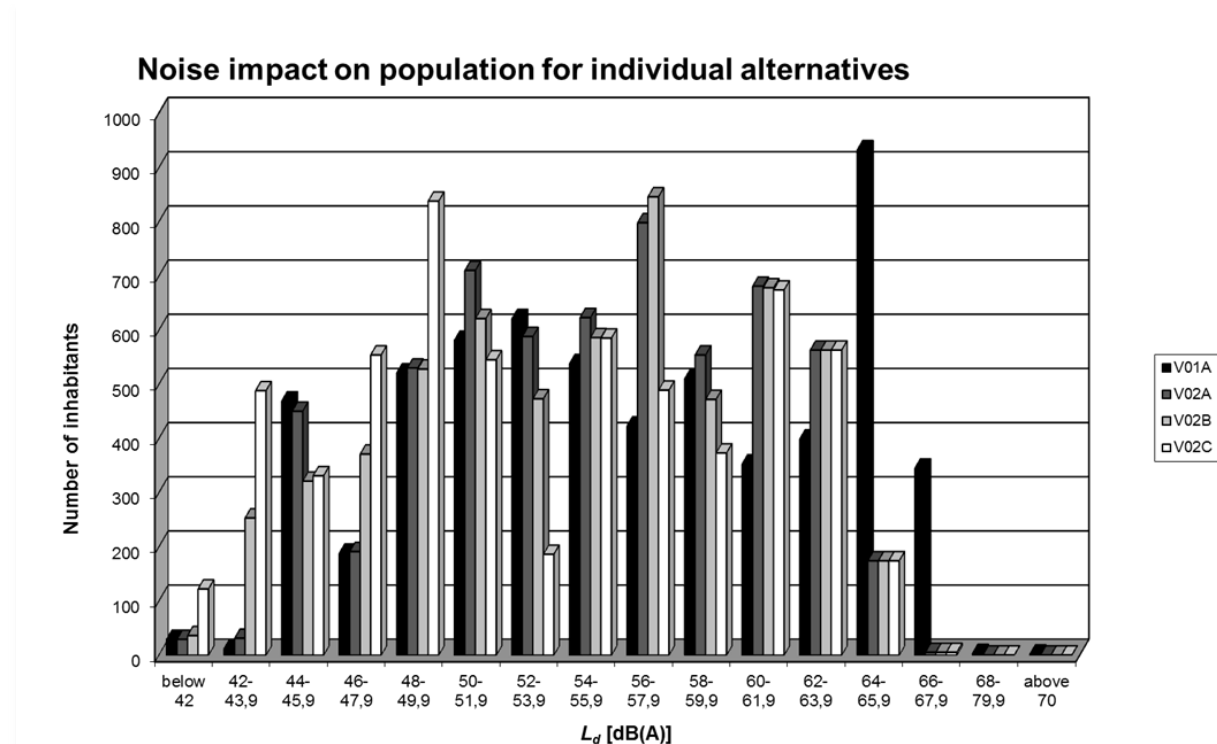


Figure 3: Noise impact on population for low-noise road surface in combination with speed reduction.

The installation of a 3 m high anti-noise barrier in the vicinity of the trunk road has a partial effect on the number of noise affected inhabitants in the most affected zone. In comparison with the low-noise road surface, this measure is not as effective in the most affected zone due to several reasons. There are a number of turn-off roads to the residential area and the anti-noise barrier is not consistent – noise may spread to the residential area through the gaps. Furthermore, a 3 m high anti-noise barrier is unable to protect multi-storey buildings – this measure is totally ineffective for higher floors. Regarding the aggregation of data over more zones, see Figure 4, this measure shows a higher effectiveness, which stems from noise damping behind the obstacle of an anti-noise barrier. In this case the impact of noise is reduced over several zones.

Noise impact on population for individual alternatives at the aggregation in 10 dB zone

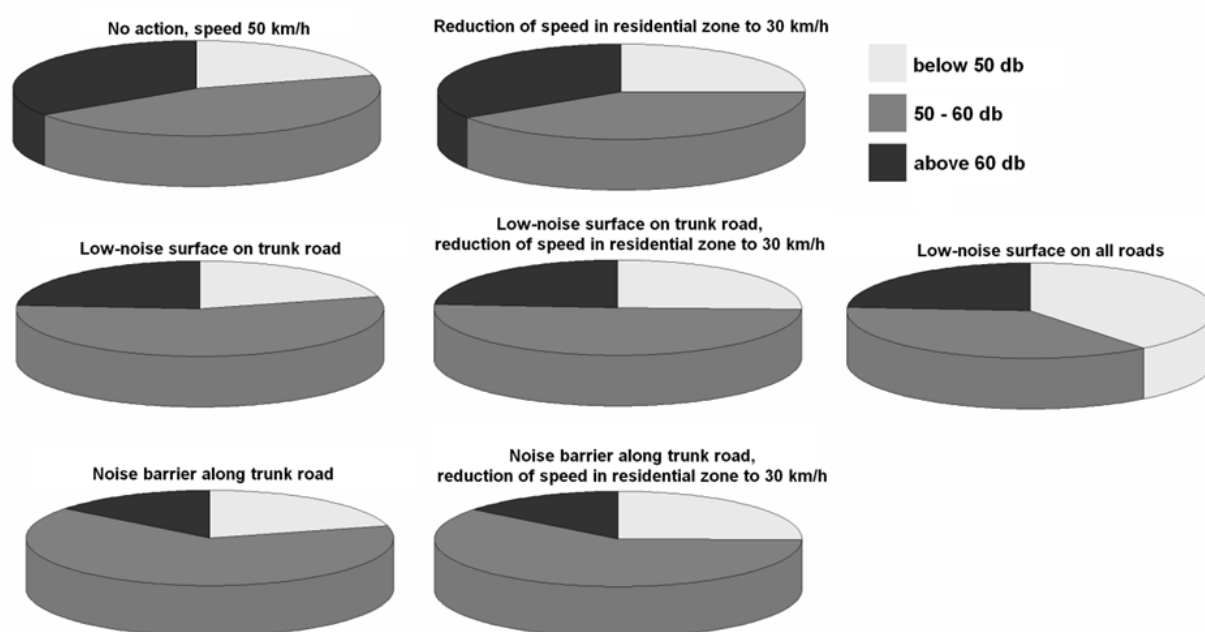


Figure 4: Noise impact on population for individual alternatives at the aggregation in 10 dB zone.

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