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Simulation on implementing noise mitigation measures in a typical urban area

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Abstract. Starting from the analysis of a real situation in which the equivalent noise level was measured in a residential area, an urban area with the same characteristics was simulated. The purpose of these tests was not to determine exactly the noise level in the area, but to simulate the introduction of noise mitigation measures, and to highlight the difference between the noise level at the edge of the sidewalk and the level next to the building, at the pedestrian height. Four series of simulations were made. The first series starts from the simple situation (street with 4 traffic bands and tram line), without measures of noise reduction, for which a green area with a height of 1.50 m was implemented, a noise barrier and then both measures. The second series of simulations tests the impact that the reduced capacity of the traffic in the area may have, transforming the street into one with only two traffic bands, the remaining space being given to the sidewalk. To optimize noise mitigation, the same situations were simulated, but with the implementation of a green area of 3.00m height. Thus, it is found that the noise level decreases from 74-76 dB (A) to 58-60 dB (A), meaning a decrease of 16 dB (A). From these simulations it can be concluded that in order to reach a comfortable noise level that respects the maximum admitted level, it is recommended to decrease traffic intensity (through different interventions on road surface capacity, promoting of public transport, etc.), to implement anti-noise barriers of materials with a high sound absorption capacity and a green space with a height that exceeds the height of the anti-noise barrier and has a high density of leaves.

1. Introduction

Ambiental acoustics or environmental acoustics study the management and protection against noise produced by fixed sources (industry, education facilities, entertainment, parking, etc.) and / or mobile (underground, land and air traffic) and the possibility of creating urban areas with a strong ecological character, based on the sensations felt by people in these spaces.

Even though the vast majority of the population do not concern about the influence of noise on their health, this being acknowledged by specialists in the field, noise has negative implications on quality of life [1,2] and on the "health budget".

To reduce the level of noise experienced by humans, a series of measures can be taken, regarding:

- *reducing the noise emission* - decrease of the level of noise generated by sources, by stimulating the evolution of the transport vehicles technology; the use of electric vehicles, silent tires, etc.;
- *increasing sound absorption* on the distance between source and receiver by using sound absorbing surfaces with high noise reduction potential;
- *protecting the receiver* by urban planning measures such as:
 - placing artificial or natural screens between noise sources and pedestrians;
 - restricting and rethinking traffic on urban traffic roads;
 - creating an acoustic protection zone for the pedestrians by rehabilitating the cross-section of the streets, this protection being made of vegetal elements, where the situation allows it, or artificial ones [3].



In terms of *urban road traffic*, a number of measures have been taken in recent years in various European cities, including:

- *reducing heavy freight traffic* within the city by developing logistics centres outside the cities and using low noise emission vehicles for the distribution of goods in dense urban areas;
- *directing the traffic to less sensitive areas*: limiting streets that allow agglomerations of cars to cross residential areas, those being directed to mainly industrial areas;
- *improvement and homogenization of traffic* by: designing of appropriately dimensioned roundabouts, imposing speed restrictions, implementation of a traffic light management system, synchronized with the volume of traffic, so that stops and starts are limited, traffic becoming fluidized;
- *promoting public transportation*, by creating special bus lanes, implementing a traffic light system with priority for public transport at intersections, setting up optimized routes so that public transport would become much easier than the use of one's own vehicle, which will lead to a decrease in the number of cars in the urban environment;
- *implementation of a "park & ride" system* - parking spaces located on the main entry roads into the cities, directly linked to the main points of interests by means of public transportation;
- *encouraging the use of bicycles* - by designing suitable bicycle paths, separated from roads and pedestrian traffic, for reasons of safety and fluidity of transport;
- *redesigning the cross-section of streets* - the Copenhagen model - limiting the number of lanes for cars, which are transformed into public transportation areas, bicycle lanes or green spaces, thus increasing the distance between the noise sources and the pedestrians. This measure can lead to the decrease of traffic volume, the transformation of the street from a traffic-only street into a space dedicated to people with a high degree of comfort [4].

This study aims to analyse the impact of some noise mitigation measures on its level as it is perceived by the pedestrians at the street level.

2. Description of the study

The study presented in this paper is based on the analysis of a real situation, presented in the paper [4]. The studied area is located between the intersection of Nicolina Street and Alea Rozelor (figure 1), in the city of Iasi, Romania. Nicolina Street is a 2nd category street, according to STAS 10144 / 1-90 [5], with four lanes, and it is bordered by collective houses on both sides, of five storeys high. Road traffic is continuously pulsating, the number of vehicles registered over one day being over 11 000. According to the noise map of Iasi, the noise level is very high near the buildings on this street ($L_{zsn} > 75\text{dB}$) [6]. The measurement for the noise map study were made at a time when there was no noise barrier in the area. In 2015, along with the street rehabilitation, a protective barrier was mounted on the sidewalk, with the purpose of limiting the propagation of traffic noise.



Figure 1. Studied area in Iasi, Romania [4].

According to the measurements made in this area, the following values of the equivalent noise level were determined:

- at the road edge – 74.17 dB(A)
- behind the acoustic panel – 65.62 dB(A)
- next to the building (at a distance of 2.00m) – 56.75dB(A)

It can be noted that the noise levels exceed the legal limits, both at the road edge (legal limit of 70 dB(A) according to STAS 10009-88 [7]), and also next to the facade of the residential building (legal limit of 50 dB(A) according to C 125-133 [8]).

Starting from the analysis of the real situation presented above, an urban area with the same characteristics was simulated:

- buildings have a height of 16 m, the same as a 5-storey block of flats;
- the distance between the two opposite buildings is 40 m;
- the street was considered to be of 2nd category, connecting road, with four lanes and tram line;
- the distance between the street and the buildings is 12.00 m.

According to the Technical Norms of 27.01.1998, regarding the design and construction of streets in urban areas, a traffic intensity of 360-600 automobiles / hour / band [9] is considered for a 2nd category street. The simulations were made using SoundPlan. To calculate the emission level, the software needs some input factors: the number of lanes and their width, the type of road surface, the number of light and heavy vehicles that pass throughout the street, the type of trams that are used (which you can choose from a library) and the maximum legal speed [10]. The simulations took into account the minimum number of cars scheduled (360). The number of trams passing through the area was considered to be 1 tram / 30 minutes. The simulations only took into account the day period (07:00 – 19:00).

The purpose of these tests was not to determine exactly the noise level in the area but to simulate the introduction of noise mitigation measures and to highlight the difference between the noise level at the pedestrian height of 1.70 m, near the building, for each of the tests. The pedestrian was considered at a distance of 2.00 m from the building.

3. Tests results

Figure 2 shows the simple street situation with 4 lanes and a tram line without any noise mitigation measures. It is noted that the noise level recorded near buildings is between 74 and 76 dB(A). The following test implies the placement of a green space with a width of 5 m and a height of 1.50 m. A decrease of the noise level is observed, having values between 70 and 72 dB(A) next to the building (figure 3).

The third test takes into consideration the setup of a noise barrier at the edge of the pavement, with a height of 2.00m. The program has the option of choosing a slightly absorbent barrier with a noise reduction level of 4 dB(A), which corresponds to an absorption coefficient $\alpha = 0.6$. In this test, there is a decrease in the noise level recorded near the building, which is between 68 and 70 dB(A) (Figure 4).

The fourth test takes into account the implementation of both noise mitigation measures (1.50m green space and 2.00m noise barrier) resulting in a noise level between 66 and 68 dB(A). It can be noticed that the implementation of both noise protection measures has the greatest impact on it, the decrease of the noise level being of approx. 8 dB(A) (Figure 5).

The second series of simulations tests the impact that the reduced traffic capacity in the area might have, by transforming the street into one with only two lanes, the freed space being given to the sidewalk (figure 6). This change results in a noise level near the building of 70-72 dB(A), with 4 dB (A) less than in the 4-lanes situation. As in the first series of tests, the following noise mitigation options were implemented:

- a green space with a width of 5 m and a height of 1.50m (figure 7);
- noise barrier with the height of 2.00m (figure 8);
- both measures of noise mitigation (figure 9).

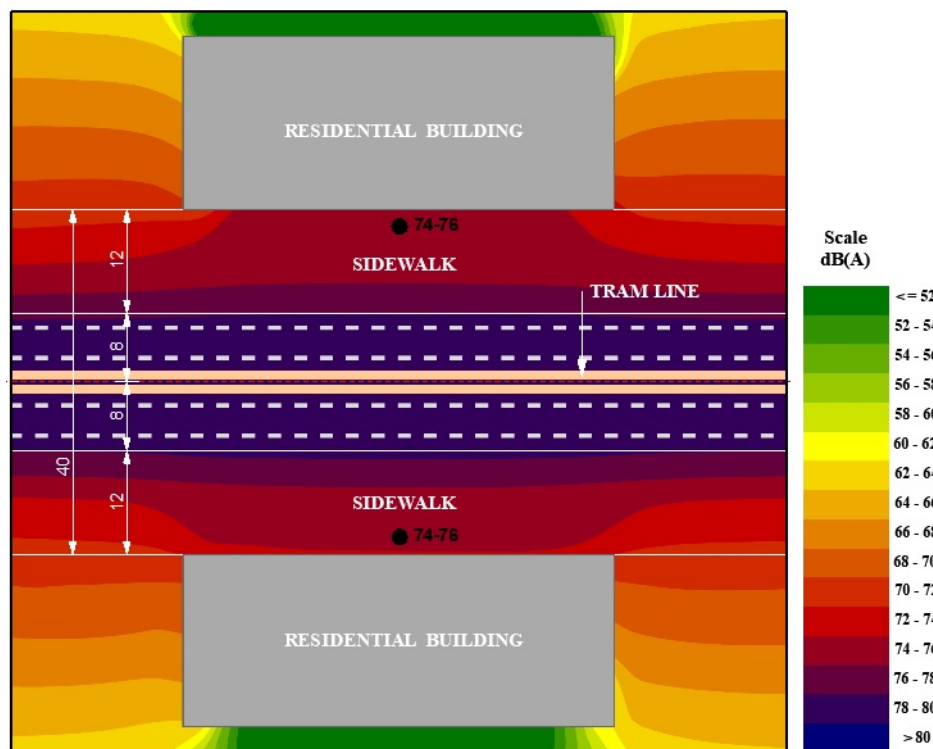


Figure 2. Noise level simulation for a street with 4 lanes and tramway, without noise mitigation measures.

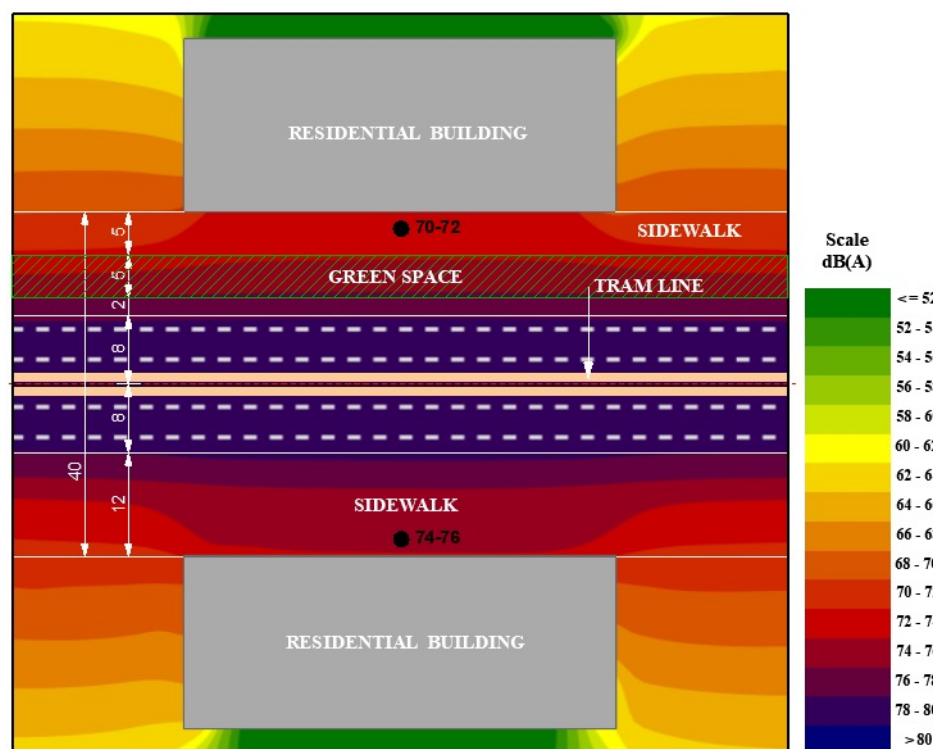


Figure 3. Noise level simulation for a street with 4 lanes, tramway and green space ($h = 1.50\text{m}$).

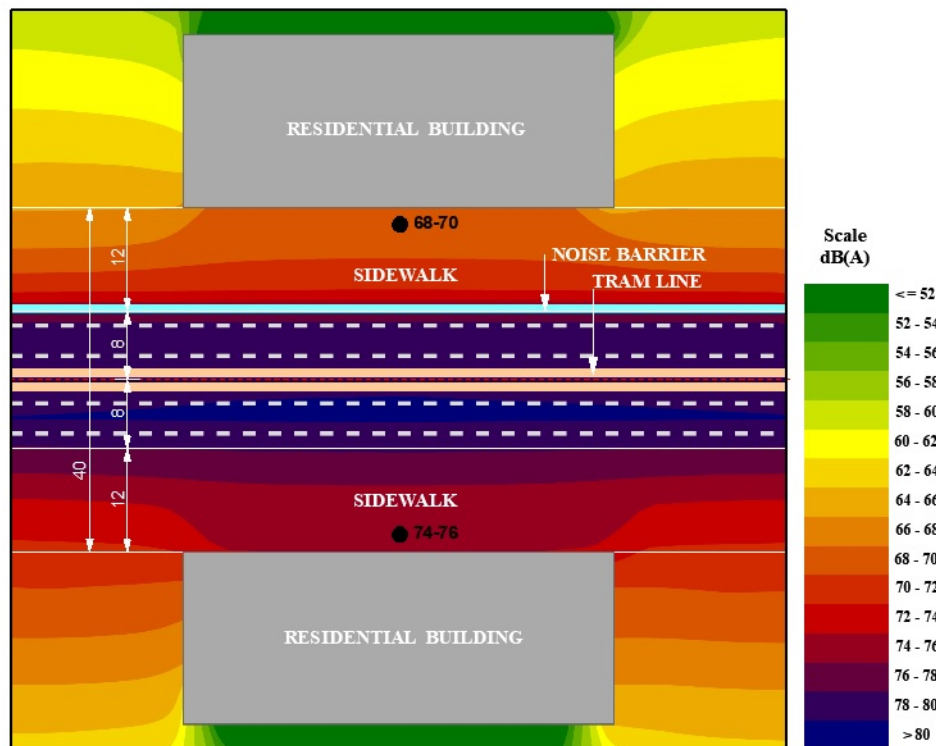


Figure 4. Noise level simulation for a street with 4 lanes, tramway and noise barrier ($h = 2\text{m}$).

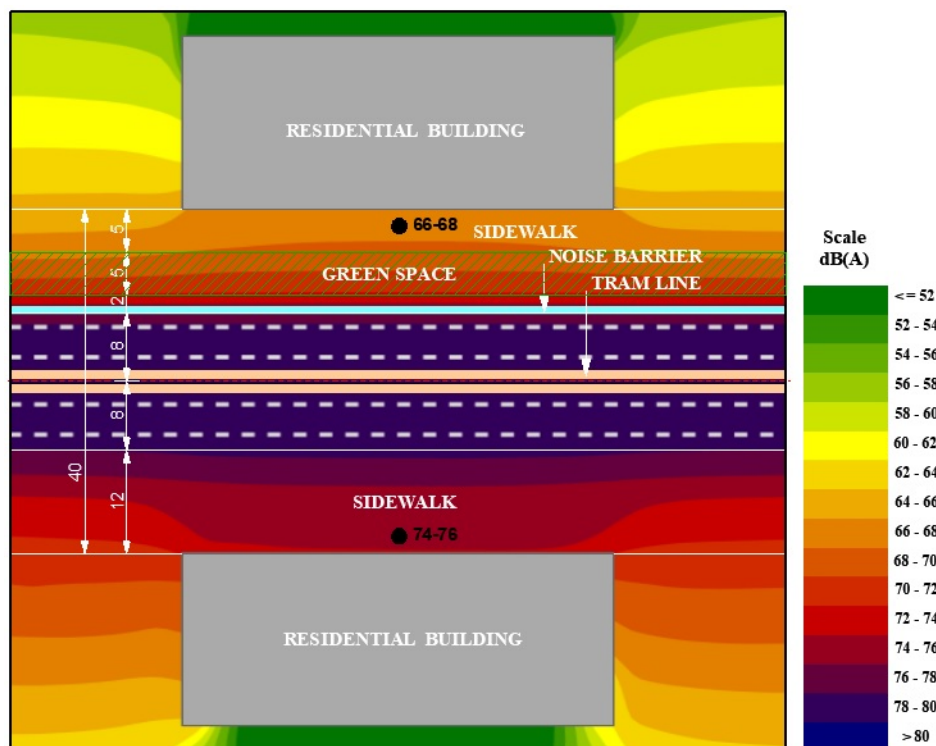


Figure 5. Noise level simulation for a street with 4 lanes, tramway, green space ($h = 1.50\text{m}$) and noise barrier ($h = 2\text{m}$).

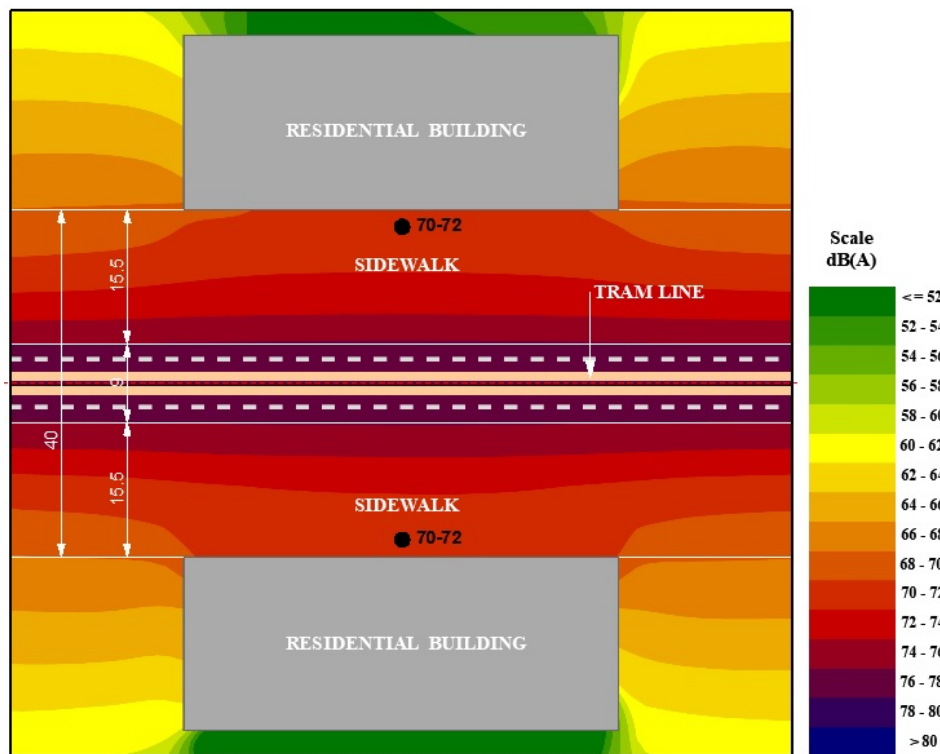


Figure 6. Noise level simulation for a street with 2 lanes and tramway, without noise mitigation measures.

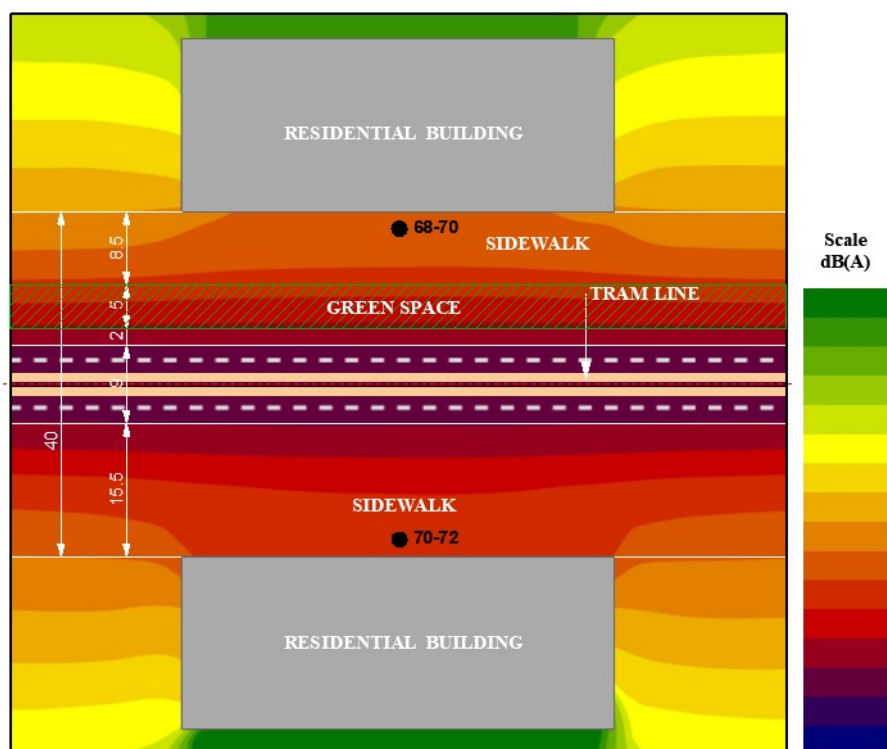


Figure 7. Noise level simulation for a street with 2 lanes, tramway and green space ($h = 1.50\text{m}$).

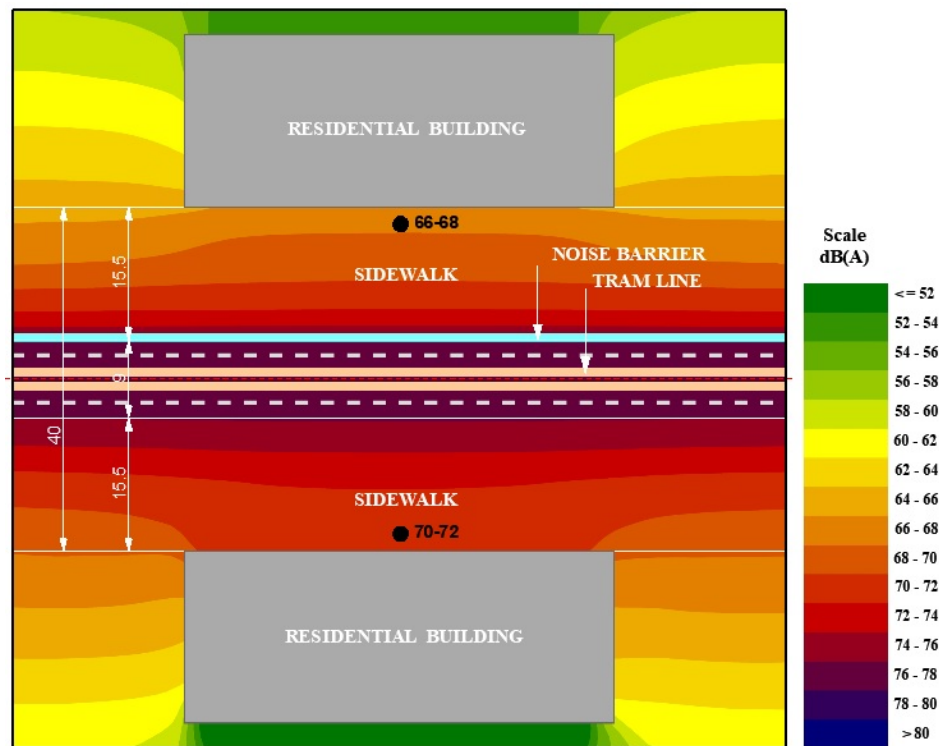


Figure 8. Noise level simulation for a street with 2 lanes, tramway and noise barrier ($h = 2\text{m}$).

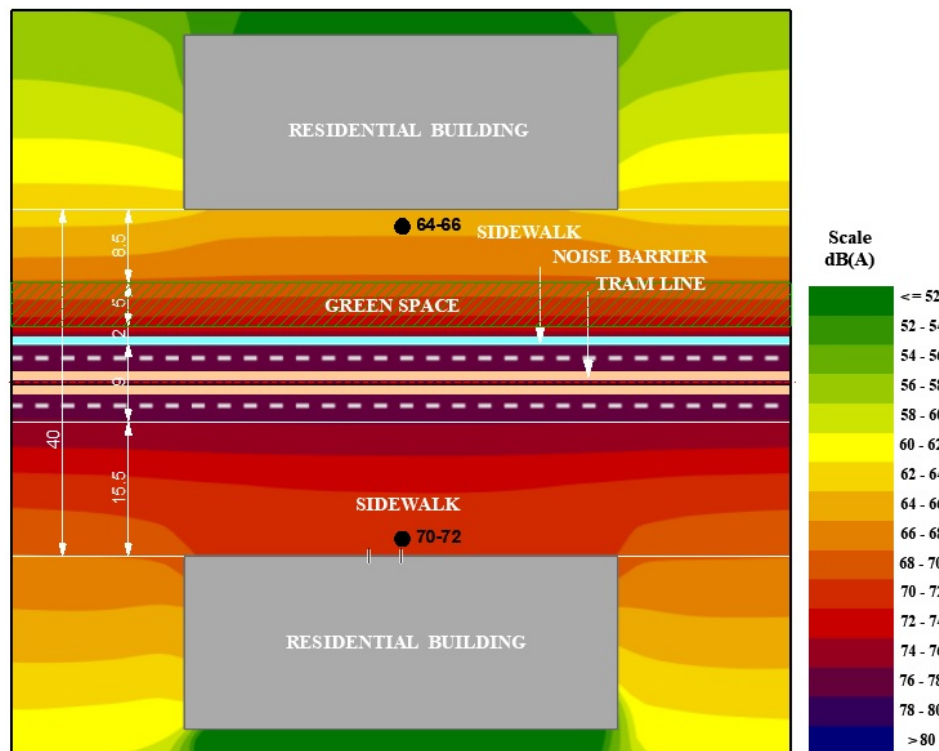


Figure 9. Noise level simulation for a street with 2 lanes, tramway, green space ($h = 1.50\text{m}$) and noise barrier ($h = 2\text{m}$).

By drawing a cross-sectional profile of the street, it can be noted the decrease of the noise level due to the implementation of the noise barrier and the green space. Figure 10 shows the street situation with 4 lanes, and Figure 11 shows the street with 2 lanes. The smallest noise level is 64 dB(A), obtained in the situation of the street with only two lanes, anti-noise barrier and green space with a height of 1.50m. However, the values obtained are above the limit allowed by Norm C 125 - 2013 of 50 dB(A), measured at 2.00 m distance from the residential building.

From these tests it can be concluded that if we would consider the reduction of the road surface to only two lanes, than the recorded level (without protection measures) would be 4 dB(A) lower than in the case of the street with 4 lanes. In case of implementing the green space and the noise barrier, the recorded pedestrian level would be 64-66 dB(A).

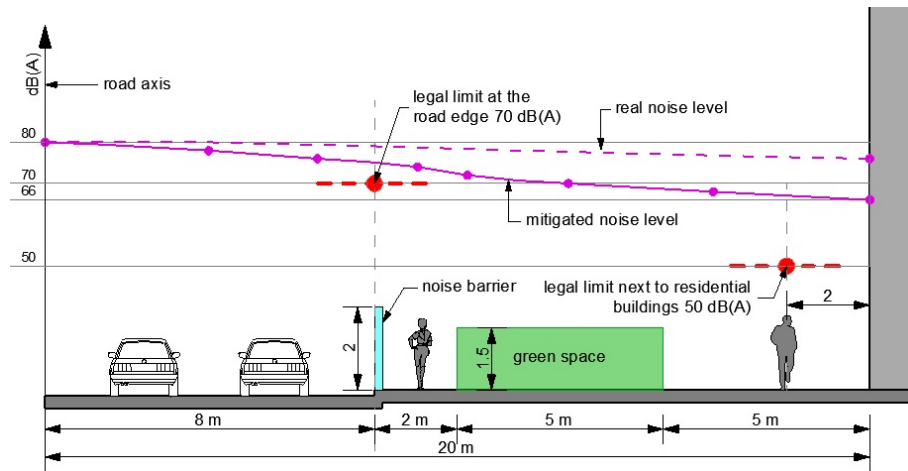


Figure 10. Highlighting the noise level - cross-sectional profile of 4 lanes street with barrier and green space ($h = 1.50\text{m}$).

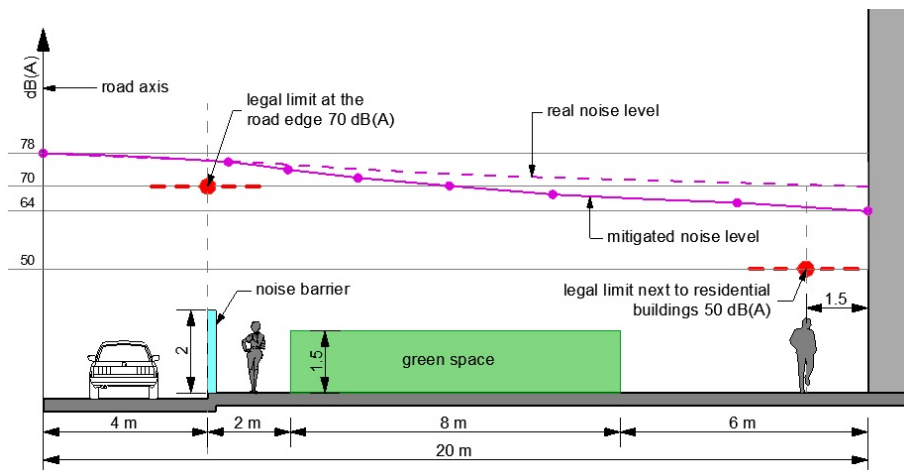


Figure 11. Highlighting the noise level - cross-sectional profile of 2 lanes street with barrier and green space ($h = 1.50\text{m}$).

To optimize noise attenuation, it was decided to simulate the same situations, but with the implementation of a green space of 3.00m height. This change led to the next distribution of the noise level presented separately for the 4-lanes street (Figure 12) and the 2-lanes street (Figure 13).

By drawing the cross-sections of these situations, a minimum noise level of 62 dB(A), for the 4-lane street and 58 dB(A), for the 2-lane street (Figures 14 and 15), is observed. Figure 16 presents

comparatively all the cross-sectional profiles of this road, with the highlighting of the noise level obtained in the simulations.

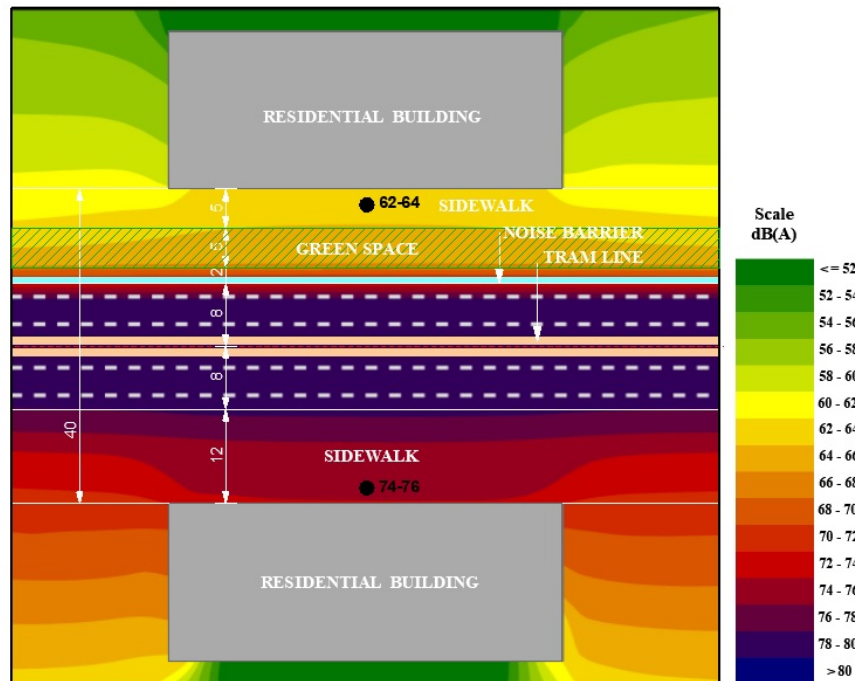


Figure 12. Noise level simulation for a street with 4 lanes, tramway, green space ($h = 3.00\text{m}$) and noise barrier ($h = 2\text{m}$).

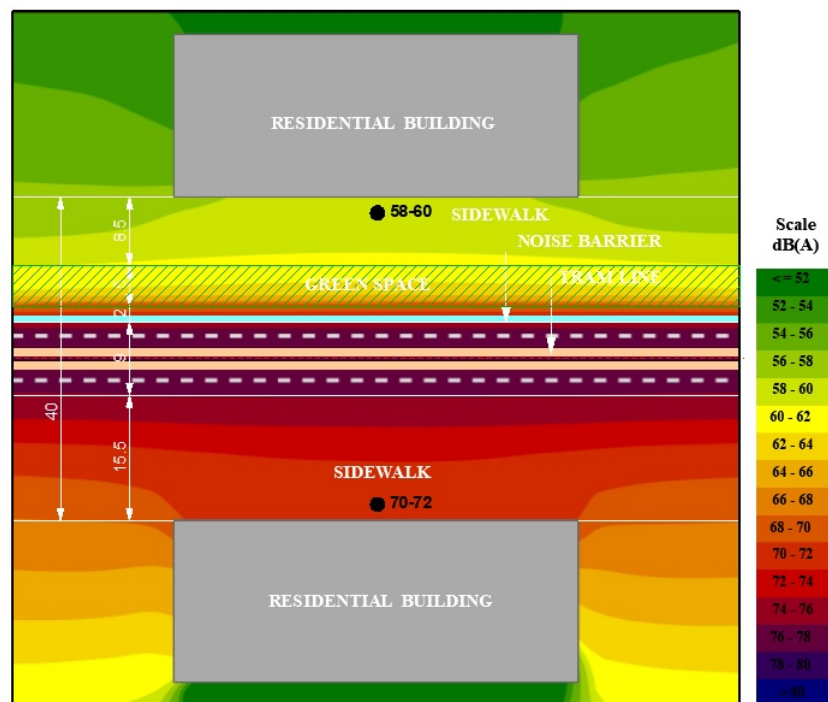


Figure 13. Noise level simulation for a street with 2 lanes, tramway, green space ($h = 3.00\text{m}$) and noise barrier ($h = 2\text{m}$).

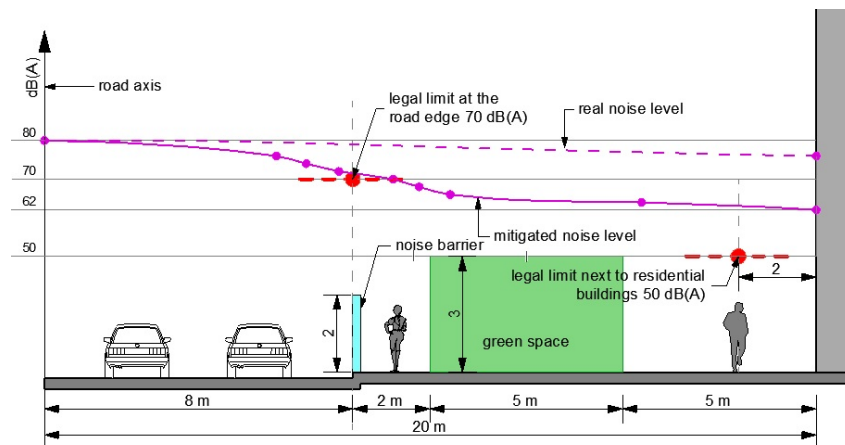


Figure 14. Highlighting the noise level - cross-sectional profile of 4 lanes street with barrier and green space ($h = 3.00\text{m}$).

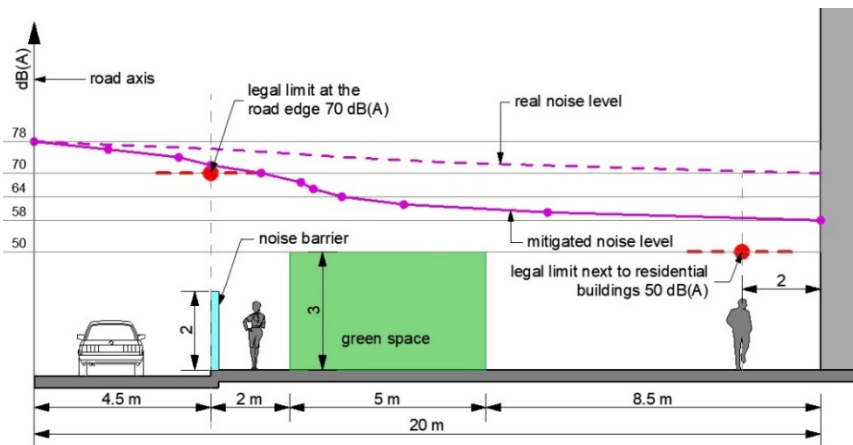


Figure 15. Highlighting the noise level - cross-sectional profile of 2 lanes street with barrier and green space ($h = 3.00\text{m}$).

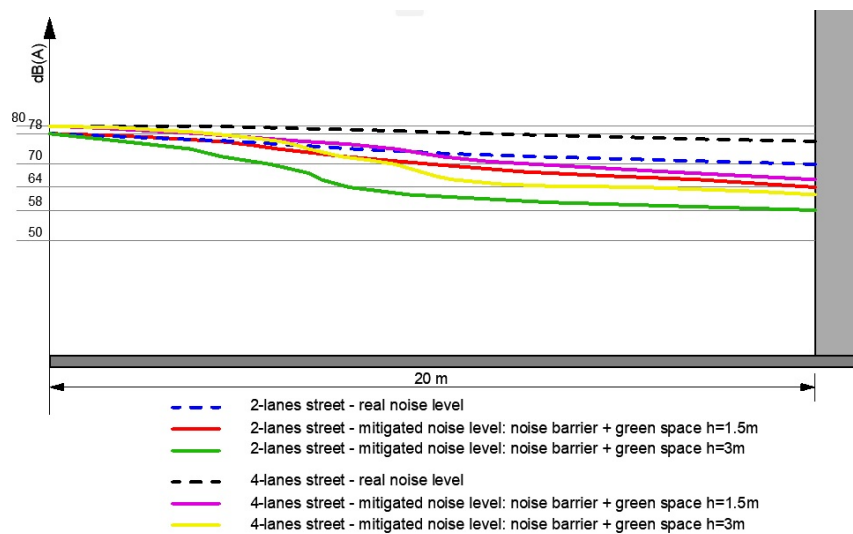


Figure 16. Highlighting the noise level - cross-sectional profile for all the simulations.

By comparing the cross sections for this street type, with the distance between the road axis and the residential buildings of 20m, it is noticed that the greatest impact on the noise level was achieved in the case of reduced traffic surface and the implementation of noise protection measures: noise absorption barrier (with a noise reduction level of 4 dB(A)) and green space with a height of 3.00 m.

4. Conclusions

Of all these tests, it can be concluded that the implementation of a green space of 3.00m height and a 2.00m noise barrier without considering a very absorbent material leads to a decrease in the level of pedestrian noise of around 12 dB(A) both for the 4 lane street and for the 2 lane street. If we were to consider the mitigation of the street capacity, from 4 lane to 2 lane street, than we could achieve a 16 dB(A) decrease in noise level, its value being 58-60 dB(A).

If the height of the green space is only 1.50m (the mean height of a hedge), the influence on the noise level is insignificant, as can be seen in figures 10 and 11. In the case of a green space height of 3.00m, the minimum noise level is 58 dB(A), while, when the green space is 1.50m high, the minimum noise level is 64dB(A). In order to have a positive impact in terms of acoustic comfort, the green space must significantly exceed the height of the acoustic barrier.

From these simulations it can be concluded that in order to reach a comfortable noise level that respects the legal limit, it is recommended to decrease traffic intensity (through various interventions on road surface capacity, promoting the public transport, etc.), to implement noise barriers of materials with a high sound absorption capacity (soft porous materials such as organic fibers or foam plastics) and a green space with a height that exceeds the height of the noise barrier and has a high density of leaves.

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