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Analysis of the impact of the forecasted and measured traffic intensity on noise range

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Abstract The article presents the assumptions of traffic intensity for a selected road section, which have been verified on the basis of measurements and data provided from General Measurement of Traffic (GPR). On this basis, simulations of noise ranges were made in the SoundPlan program. The simulations were performed for both predicted and verified traffic. Such simulations in the form of acoustic maps were used to determine the impact of the discrepancy between the assumed traffic intensity and that verified by measurements on noise range and its impact on protected areas and building development in the nearest vicinity.

Keywords: traffic, equivalent sound level, SoundPlan.

1. Introduction

Road noise is one of the most common sources of environmental pollution in the vicinity of residential areas [1]. Such noise can be reduced by the introduction of quiet pavements [2] or acoustic screens [3]. The search for prediction models for traffic noise forecasting is one of the most anticipated solutions in the fight against traffic noise [4]. Such models are an important tool in road planning and in assessing the impact of traffic noise on the inhabitants of the surrounding areas [5]. Many models have been developed to facilitate the prediction of traffic noise. Such models include: the FHWA road noise prediction model in the United States [6], the CRTN model in Great Britain [7], the RLS90 model in Germany [8], and the ASJ RTN model in Japan [9]. In addition, some specific models of intersections [10] and roundabouts [11] are contained in the category of steady-state calculations.

Another approach to modeling road noise emissions is the use of the Monte Carlo method [12, 13]. In the literature, also more advanced methods of road noise forecasting can be found, based on the model of probability distribution of vehicle noise emissions [14]. Numerical modeling often uses the SoundPlan software [15] using the NMPB (Guide du Bruit) noise emission model based on the PN ISO 9613-2 standard [16]. In the article, we present a preliminary proposal to verify the impact of the discrepancies in traffic intensity forecasting in relation to reality on the distribution of noise in the environment.

2. Methodology

2.1. Traffic intensity tests

The measurements of 'in situ' traffic intensity were carried out simultaneously with noise measurements on 2005 and 2008, in favorable weather conditions (good visibility, no precipitation, which offered good legibility of registration plates and silhouettes of the observed vehicles). Within the analyzed section of the road, there is one section that is homogeneous in terms of traffic intensity, i.e. between the junctions: "Wirek" and "Batory".

The measurements were made in one cross-section of the road (PR_1), and they were carried out using the classical method by taking records on typical measurement sheets, making an allowance for the generic and directional structure of the vehicles. The said structure included passenger vehicles (SO), delivery vehicles (DO), trucks (C), TIR (CC), buses (A), motorcycles (M) and others. In the final list, they were divided into light and heavy vehicles. Simultaneously with the measurement of traffic in the vicinity of the analyzed road system, the following were carried out:

– measurement of the speed of passing vehicles with the determination of directional and generic structure,
– taking records of meteorological conditions.

2.2. General traffic measurement

General Measurement of Traffic (GPR) is carried out once every five years for all national roads administered by the General Directorate for National Roads and Motorways (GDDKiA). It consists in conducting direct measurements of traffic, and its main purpose is to obtain detailed information that is used in many different fields, e.g. for planning or design purposes, they are used to update the organization of road traffic or assess the impact on the natural environment. The measurements are made using various methods, from those performed manually by observers, to the most precise ones performed by video recorders which ensure full documentation of the measurement and its extensive verification. One of the methods of traffic forecasting is the method based on Gross Domestic Product (GDP) growth rate. For planning and design purposes, General Directorate for National Roads and Motorways recommends using uniform projected GDP growth rates at the average level. The maximum value of the forecasted GDP growth rate is used to prepare long-term plans for the strategic development of road network, and the minimum value is used to analyze the profitability of projects. This method also uses the so-called elasticity coefficient W_e, which, when multiplied with the indicator of the annual percentage growth of GDP, allows for the calculation of the indicator of the annual percentage increase in traffic. The value of the elasticity coefficient depends on the vehicle category (bus, passenger car, truck, etc.). The elasticity coefficient W_e, which makes the traffic growth rate dependent on the GDP growth rate in particular time periods, is presented in Table 1.

Table 1. Elasticity indicator in years [17].

Vehicle category	W_e (elasticity indicator) in years	
	2006–2015	2016–2037
Passenger cars	0.90	0.80
Delivery trucks	0.33	0.33
Trucks without trailers and semi-trailers	0.35	0.35
Trucks with trailers and semi-trailers	1.07	1.00

3. Results and their discussion

At the beginning of the study, the obtained values of traffic intensity were compared with the percentage share of heavy vehicles in the vicinity of the A4 motorway along the section from "Wirek" junction to "Batory" junction, which is summarized in Table 2 and Table 3.

Table 2. Summary of traffic intensity on the A4 motorway made as part of own measurement and GPR measurement.

Year	Own measurement		GPR measurement	
	Actual vehicles/day	Share of heavy vehicles [%]	Actual vehicles/day	Share of heavy vehicles [%]
2005	28088	11	40945	19
2008	43018	21	–	–
2010	–	–	54615	17
2015	–	–	61116	14
2020	–	–	69548	14

Table 3. Summary of the forecasted traffic intensity on the A4 motorway in 2020-2023.

Year of forecast	Traffic forecast made on the basis of GDP data				Traffic forecast made for the needs of the project		
	Actual vehicles/ day		Share of heavy vehicles [%]		Actual vehicles/ day	Share of heavy vehicles [%]	Comments
	Based on measurements from 2005	Based on measurements from 2008	Based on measurements from 2005	Based on measurements from 2008			
2010	34509	45230	10	21	–	–	–
2015	41812	51683	10	22	–	–	–
2020	49243	58630	9	22	83291	11	Based on the forecast made in 2005

The impact on the acoustic climate of the neighborhood of the road section selected for analysis was determined based on simulation calculations made for acoustic-geometric models. To create them, a digital 3D terrain model was used for the existing state, as well as traffic factors (vehicle intensity, speed and percentage share of heavy vehicles), geometry of noise source and the development of areas adjacent to the road. Numerical calculations were performed using the SoundPlan 8.2 package and the noise emission model NMPB (Guide du Bruit) based on the standard PN ISO 9613-2 [16]. Due to the lack of a national method for calculating the distribution of acoustic climate in the vicinity of roads, the authors carrying out the calculations used the French national calculation method "NMPB-Routes - 96 (SETRA-CERTU-LCPC-CSTB)", described in [18] and the French standard "XPS 31-133" – in accordance with Annex II to Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of noise in the environment [19]. The method makes use of the emission values published in the manual [20] as input data.

The measurements of noise and traffic intensity carried out at reference points were used to calibrate the adopted calculation model, whereof values were input quantities for the calculation of the actual noise impact ranges. The results of traffic intensity and sound levels are presented in Table 4.

It can be observed that in terms of traffic intensity, the actual results differ significantly from the forecasted ones. The GPR results from 2020 demonstrate a much higher level of traffic intensity than those calculated on the basis of elasticity coefficients. The differences are lower when the calculations concern traffic measurements from 2008 and not from 2005. It should also be noted that the forecast for 2020 made in 2005 significantly differs from the measurement results. The traffic intensity was predicted to be well over 83 000 vehicles per day, and in reality it was less than 70 000 vehicles per day.

It is worth noting that a significant difference in traffic intensity between the forecast and the GPR did not significantly affect the value of equivalent sound level. Therefore, noise range maps were made to verify how the differences between the forecast and reality affect environmental noise (see Fig. 1).

The change of noise range for such a defined area does not affect the protected objects. However, it should be noted that with a different topography and different location of the protected objects, a change in the range may be of fundamental importance.

The article presents an acoustic analysis of the impact of a fragment of the A4 motorway on the section between the “Wirek” junction and the “Batory” junction. The calculated equivalent sound level at a distance of 10 m from the extreme lane at a height of 4.0 m is 76.2 ÷ 80.9 dB during daytime and 71.0 ÷ 75.7 dB at night. With the traffic intensity in 2020, the range of the acoustic impact for the permissible level of 65 dB for daytime is between 122 ÷ 125 m, for 61 dB is 136 ÷ 216 m and for the night time and 56 dB is 136 ÷ 214.5 m.

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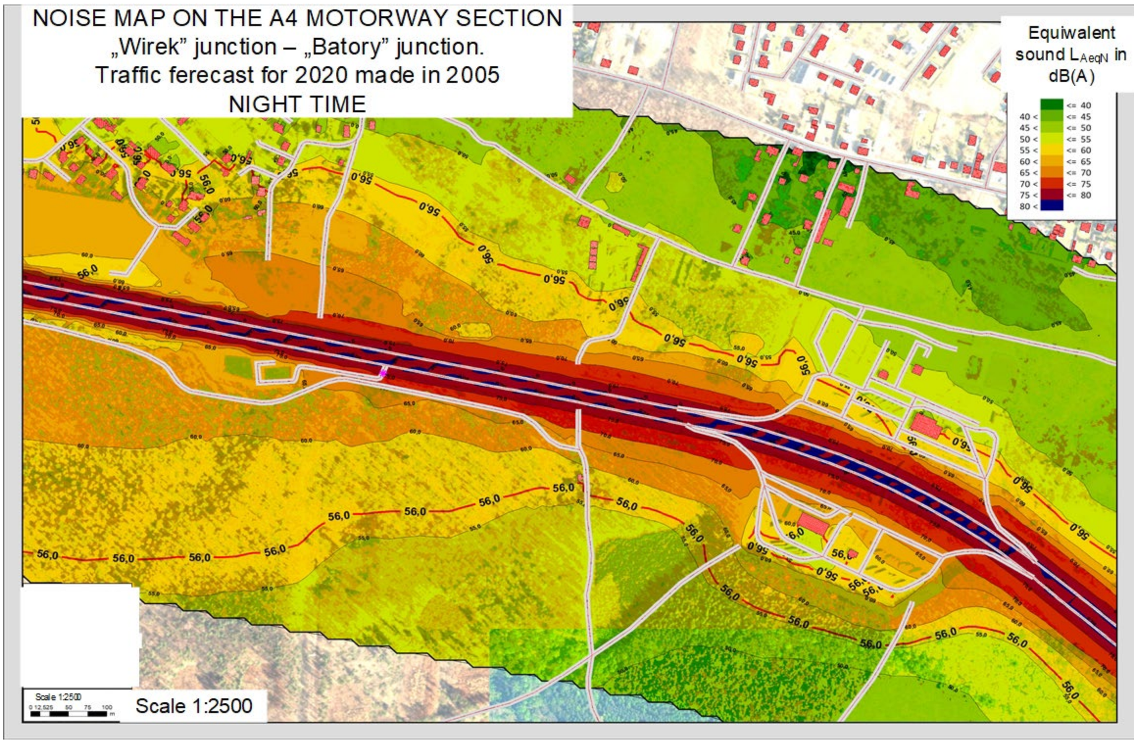
a)



b)

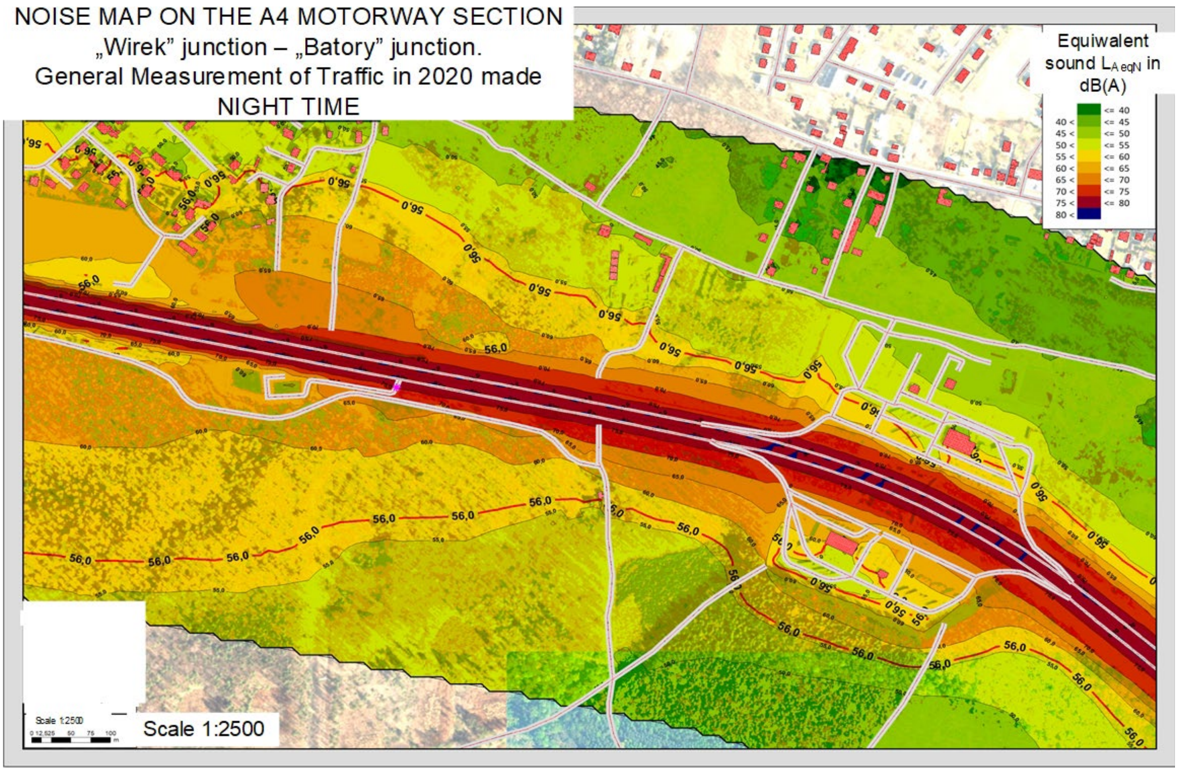


Figure 1. Noise map along the A4 motorway at night time: a) forecast for 2020 performed in 2005, b) GPR performed in 2020.

Table 4. Summary of traffic intensity in individual years along with sound levels for daytime (L_{AeqD}) and night time (L_{AeqN}) at measuring point PR1 (own measurement).

YEAR	Average annual traffic volume per day (SDRR) of motor vehicles in total		Equivalent sound level dB[A]	
	number of vehicles	source of information	L_{AeqD}	L_{AeqN}
2005	28088	own measurement	76.2	71.0
	83291	forecast for 2020 made in the current year	80.9	75.7
	40945	GPR measurement	78.4	73.1
2008	43018	own measurement	78.7	73.5
	31845	own measurement from 2005 calculated with the elasticity coefficient for the current year	76.7	71.5
2010	54615	GPR measurement from the current year	79.5	74.3
	34509	own measurement from 2005 calculated with the elasticity coefficient for the current year	77.1	71.8
	45230	own measurement from 2008 calculated with the elasticity coefficient for the current year	78.9	73.7
2015	61116	GPR measurement for the current year	79.8	74.6
	41812	Own measurement from 2005 calculated with the elasticity coefficient for the current year	77.8	72.6
	51683	own measurement from 2008 calculated with the elasticity coefficient for the current year	79.5	74.3
2020	69548	GPR measurement from the current year	80.3	75.1
	49243	own measurement from 2005 calculated with the elasticity coefficient for the current year	78.5	73.2
	58630	own measurement from 2008 calculated with the elasticity coefficient for the current year	80.1	74.9

4. Conclusions

In the summary of the work, the most important conclusions can be presented:

- The forecast for 2020, made in 2005, amounted to 83 291 vehicles per day, while the GPR measurement indicated the level of 69,548 vehicles per day, while the calculation with the elasticity coefficient indicates the level of 49 243 vehicles per day (for the measurement database from 2005) and 58 630 vehicles per day (for the measurement database from 2008).
- The range of noise for the forecast and for the GPR measurement differs slightly for the road situation presented in this article.
- Developing, based on the currently applicable guidelines, long-term forecasts of vehicle traffic volume on the planned road sections, and thus assessing the risk of exposure to road noise of local residents, is very difficult and is usually underestimated.
- Forecasts developed in 2002 overestimated the volume of vehicle traffic both on the planned section of the S1 Expressway and on the existing section of the A4 Motorway.

Additional information

The authors declare: no competing financial interests and that all material taken from other sources (including their own published works) is clearly cited and that appropriate permits have been obtained.

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