11

NOISE EMISSIONS TEST FROM THE COMMUNICATION ROUTE – A CASE STUDY

11.1 INTRODUCTION

In large cities, the quality of existence residents is dependent on many factors including the quality of the environment. One of the factors affecting the quality of life of the acoustic emission generated and emitted from the passageways. However, more can be said about noise occurring because the value of the issue often exceeds acceptable level of nuisance noise. Noise from traffic routes is generated by car engines that produce low-frequency sounds, and is a result of the effect of turning the wheels of vehicles on the road surface and in this case the noise is a high frequency sound [6]. However, in practice the level of road noise is a function of many variables. These include, among others: the type, quality and condition of the road surface, number of lanes and their distance from residential development, the number of vehicles passing per unit of time, the structure of daily traffic volume, type of vehicle and its condition, traffic variability forced by his specific organization, the number of intersections regulated by traffic lights, the duration of one cycle traffic light changes or the right of its synchronization by creating a so-called. "Green wave" [9]. The undeniable fact is that the number of moving the high-traffic urban vehicles such as cars and trucks, is constantly increasing, as a result there is an increase in noise level.

Against this unfavorable environmental influences on recent changes existence man came to European Union legislation. Adopted in 2002 by the EU Directive, which sets out the approach to the assessment and management of environmental noise in order to protect public health. He treats it as noise pollution, to which you should take the same general principles, responsibilities and forms as for the other pollutants and related environmental fields. Entered on January 23, 2008, the amended Environmental Protection Act (consolidated text. Laws of 2008 No. 25, item. 150) is also the result of alignment with EU standards. Currently applicable legal act regulating the levels of noise is the Minister of Environment of 14 June 2007 (Journal of Laws No. 120, item 2007. 826) together with the amendment of 2012.

One of the factors of the environment, on which the alleged nuisance is often especially in big cities, of course, noise. This subjective sound level as a nuisance is determined by each person individually. This is due, of course, the individual characteristics of man and his acceptability threshold sound level for proper the functioning and existence. Classification of the noise produced by the National Institute of Hygiene in Warsaw on the basis of the respondents, which is related to the value of an equivalent level L_{Aeq}:

– small nuisance $L_{Aeq} < 52$ dB,

– average nuisance 52 dB < L_{Aeq} < 62 dB,
– big nuisance 63 dB < L_{Aeq} < 70 dB,
– a very big nuisance 70 dB < L_{Aeq} [6].

Well-being of residents of large cities often depends on the ambient sound from of climate life. In order to improve the acoustic climate has already made a number of steps relating to, inter alia, the implementation of noise barriers or other technical means, but also the mapping of acoustic and acoustic monitoring. Nevertheless, in this area there is still much to accomplish and it is on many levels.

Like many Polish cities, Zabrze also facing the problem of excessive noise, and residents often raise the problem of noise nuisance, among others. in the communication al. W. Korfantego where is a high traffic area, a study conducted in 2011 [4] showed a negative acoustic climate in the region.

11.2 OBJECT OF RESEARCH [4]

Object of traffic noise emission test covers part of the avenue W. Korfantego in Zabrze, where the research was conducted in six measuring points, plus the points of reference. Avenue is a road connecting the district center of Zabrze Mikulczyce of the two-lane asphalt pavement (roadways separated by a green belt) with three lanes in each direction.

This thoroughfare are moving several thousand vehicles per day. Moving vehicles are not only cars, but also provide a large number of lorries and buses. Along the avenue are located ten-apartment buildings with a height of about 30 meters. These buildings are not protected acoustically according to [5], and the inhabitants raise the problem of excessive noise.

According to the Minister of Environment of 14 June 2007 (Journal of Laws of 2007 No. 120, item. 826) [7], the area in which the measurements are classified as multi-family residential areas and living collections. Under that regulation, revised in 2012 for the analyzed area limits are as follows:

– 65 dB $L_{Aeq\ D}$ (equivalent sound level for the time of day, understood as the period of time from 6 hours to 22 hours),
– 56 dB $L_{Aeq\ N}$ (equivalent noise level for night time, understood as the time interval from 22 hours to 6 hours 6).

In order to determine whether these values are standardized satisfied, measurements were performed at six points. Measuring point first and sixth to end points on the test section of the road. Measuring points, second and third were chosen to measure the noise running on the roadway, and the fourth measurement point on the area included in the next row in the space between the buildings of the first row. Fifth measurement point was located close to the road in such a way as to measure the noise, which runs on Albert's house, located on this street (background measurements were carried out in the additional points for buildings – fig. 11.1).

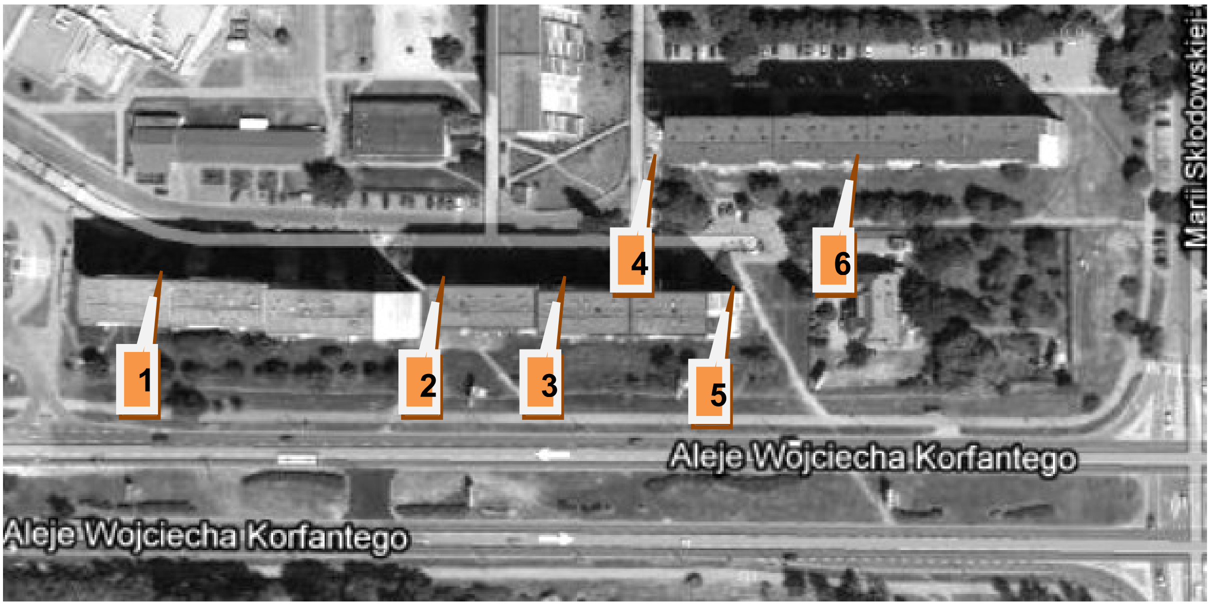

Fig. 11.1 Satellite view from Google Maps Avenue W. Korfantego with marked test points

11.3 DESCRIPTION OF THE MEASURING APPARATUS AND TEST METHOD

Acoustic measurements were made using a measuring kit comprising:

- sound level meter and vibration produced by SVAN a 948 with a serial number 12631 having a calibration certificate No. 1483.1-M34-4180-411 issued by the PGUM,
- SV22 measurement microphone type of BSWA Tech/SVANTEK with a serial number 4012856 having a calibration certificate No. 1483.1-M34-4180-411 issued by the PGUM,
- a microphone preamplifier SV 12L with a serial number 17301 having no 1483.1-M34-4180-411/08 calibration certificate issued by PGUM,
- Draft shield and measuring stand.

Before and after measurements of a 948 SVAN analyzer with measurement microphone type SV22 company BSWA Tech/SVANTEK marked with acoustic calibrator type SV30 No. 14155 SVANTEK production, having a calibration certificate No. 1483.2-M34-4180-411 issued by the PGUM.

The measurements previously established punks used the direct method of measuring noise measurements. Performed equivalent sound level measurements were recorded at a distance of 1.5 m from the facade of buildings, at the height of 4 m, as in the year 2011. The measurements were carried out in July 2012, in the three days of the week. Weather conditions during the measurements were as follows: temperature ranging from 15°C to 25°C, relative humidity of 67% – 69%, the atmospheric pressure in the range 1044 hPa – 1069 hPa, no precipitation occurred. In order to minimize the effect of wind on the results of the microphone mounted on the windscreen. At each time point measurements were performed at five-hour intervals and the measurements of the background [8].

11.4 RESULTS OF MEASUREMENT

The results of measurements of the individual points are shown in table 11.1 and 11.2.

Table 11.1 Results of the measurement of the noise emission from test points from 1-3

Interval	Measurement point 1			Measurement point 2			Measurement point 3		
	L_{Aeq}	L_{Aeq}	L_{Aeq}	L_{Aeq}	L_{Aeq}	L_{Aeq}	L_{Aeq}	L_{Aeq}	L_{Aeq}
06:00 – 07:00	58.9	57.9	58.9	54.1	552	55.0	53.9	56.3	56.5
07:00 – 08:00	62.1	63.1	61.9	58.9	56.8	56.3	59.2	57.5	58.1
08:00 – 09:00	61.9	62.8	61.3	55.8	56.7	56.4	56.8	58.5	58.3
09:00 – 10:00	61.5	61.2	62.3	57.5	55.9	56.7	57.7	58.4	57.8
10:00 – 11:00	63.2	63.4	67.4	55.9	57.1	56.4	59.1	57.6	57.9
11:00 – 12:00	64.3	63.2	62.4	61.3	57.2	57.6	58.5	57.4	59.4
12:00 – 13:00	63.4	64.1	65.2	56.4	57.8	58.2	56.7	57.3	57.3
13:00 – 14:00	64.4	62.5	63.2	55.8	58.2	57.1	56.8	57.6	58.4
14:00 – 15:00	65.4	66.0	67.9	65.7	64.8	67.2	59.7	61.2	63.4
15:00 – 16:00	68.9	69.2	69.4	65.6	63.1	67.8	59.8	59.0	58.4
16:00 – 17:00	74.8	75.5	74.5	73.5	72.3	71.6	64.9	65.6	63.2
17:00 – 18:00	74.3	73.1	74.2	61.8	60.1	58.9	61.2	62.7	59.3
18:00 – 19:00	72.1	73.2	72.3	59.9	59.6	58.3	59.2	59.4	58.5
19:00 – 20:00	68.1	69.2	68.7	57.9	57.5	58.1	59.2	58.7	58.2
20:00 – 21:00	61.1	63.2	61.1	58.9	56.4	57.8	58.7	59.2	57.5
21:00 – 22:00	59.3	58.1	58.9	57.8	56.7	56.3	56.1	58.3	55.4
22:00 – 23:00	57.3	58.5	57.8	56.9	54.9	56.1	54.9	54.3	54.6
23:00 – 00:00	55.3	53.2	52.1	52.1	51.9	52.7	52.7	53.9	53.9
00:00 – 01:00	47.8	46.7	46.9	47.2	48.0	47.9	48.1	48.4	48.3
01:00 – 02:00	46.2	47.5	47.8	46.2	45.1	44.9	45.6	46.2	46.9
02:00 – 03:00	46.6	48.3	47.9	48.2	47.6	47.7	47.6	46.4	46.8
03:00 – 04:00	47.4	47.8	48.2	49.7	48.9	48.2	48.6	47.4	50.2
04:00 – 05:00	47.9	47.4	48.1	51.2	52.7	51.8	49.9	51.2	51.7
05:00 – 06:00	52.1	51.3	52.3	55.7	56.2	56.7	55.2	57.6	58.1

Table 11.2 Results of the measurement of the noise emission from test points from 4 to 6

Interval	Measurement point 4			Measurement point 5			Measurement point 6		
	L_{Aeq}	L_{Aeq}	L_{Aeq}	L_{Aeq}	L_{Aeq}	L_{Aeq}	L_{Aeq}	L_{Aeq}	L_{Aeq}
06:00 – 07:00	51.7	53.9	52.8	59.7	60.1	61.3	52.3	52.5	52.7
07:00 – 08:00	58.0	56.3	54.1	59.9	62.3	60.3	54.7	54.8	54.1
08:00 – 09:00	53.8	55.8	51.1	56.8	60.3	62.1	55.8	55.2	55.6
09:00 – 10:00	56.7	53.3	52.1	57.7	62.3	63.4	55.7	54.5	55.2
10:00 – 11:00	55.4	53.4	53.1	63.4	62.9	63.0	54.8	54.6	55.2
11:00 – 12:00	60.3	51.2	51.3	62.3	62.2	63.2	55.4	55.3	55.3
12:00 – 13:00	56.6	57.4	55.2	63.2	62.9	62.7	55.6	53.3	54.3
13:00 – 14:00	65.8	62.4	64.2	64.7	63.3	64.0	54.8	54.5	55.2
14:00 – 15:00	67.7	65.4	65.1	63.7	62.3	63.3	55.6	54.9	54.1
15:00 – 16:00	60.9	60.9	61.5	64.5	67.1	68.9	57.3	56.7	56.8
16:00 – 17:00	69.5	69.2	62.2	72.3	71.2	69.9	57.1	57.2	57.9
17:00 – 18:00	662	61.4	64.0	72.3	72.9	71.3	57.6	57.5	57.3
18:00 – 19:00	59.4	58.8	60.1	69.7	67.4	68.6	57.4	55.9	55.2
19:00 – 20:00	59.0	58.4	57.3	65.2	66.1	67.4	54.8	53.9	54.2
20:00 – 21:00	58.7	58.8	59.8	60.3	62.2	62.1	53.7	53.9	53.2
21:00 – 22:00	54.1	55.1	53.2	61.1	60.2	61.3	50.5	51.7	51.2
22:00 – 23:00	52.5	50.7	49.9	60.7	60.3	61.1	49.1	48.2	49.0
23:00 – 00:00	45.2	44.6	46.9	59.4	59.8	57.9	48.5	46.9	47.5
00:00 – 01:00	44.9	44.6	45.0	57.9	58.3	58.0	45.2	45.5	44.9
01:00 – 02:00	45.2	44.5	45.4	55.8	53.7	52.3	45.2	44.2	45.7
02:00 – 03:00	44.5	44.2	43.1	52.8	51.4	52.8	45.6	44.3	43.4
03:00 – 04:00	45.1	44.3	44.2	48.9	49.8	48.3	48.4	46.9	47.5
04:00 – 05:00	44.7	44.6	45.5	48.9	49.3	49.5	44.7	45.3	46.1
05:00 – 06:00	47.6	46.9	46.5	59.9	59.4	59.1	50.0	51.3	51.4

11.5 DETERMINATION OF UNCERTAINTY IN MEASUREMENT AND ANALYSIS OF RESULTS

In a further stage, calculated in accordance with (11.1) [8] has a level equivalent to the sum of listening situations for each of the division of the measuring point on the time of day and night for the test results obtained in tables 10.1 and 10.2:

$$L_{Aeq} = 10 \cdot \log\left(\sum_{k=1}^{m} \frac{t_k}{T} \cdot 10^{0,1 \cdot L_{Aeq}}\right) \qquad (11.1)$$

where:

L_{Aeq} – equivalent sound level in dB acoustic situations,
$L_{em\,k}$ – equivalent sound level for a given situation in dB,
t_k – follow-up included in the normative time s,
T – normative observation time in s,
M – volume listening situations.

The results obtained from the calculation of a level equivalent to the sum of L_{Aeq} listening situations for each of the point of taking into account the time of day and night are summarized in table 11.3.

Table 11.3 Equivalent level of sound of the sum of acoustic situations for test points in the period of the day and the night

Measurment points	2011r. [4]		2012r.	
	Day time $L_{Aeq\,D}$ [dB]	For night time $L_{Aeq\,N}$ [dB]	Day time $L_{Aeq\,D}$ [dB]	For night time $L_{Aeq\,N}$ [dB]
1	64,2	49.3	**65.3**	**50.1**
2	59.5	50.2	**59.9**	**50.7**
3	58.6	50.5	**59.1**	**50.7**
4	53.2	45.5	**53.8**	**45.8**
5	63.1	55.8	**64.0**	**55.2**
6	53.8	46.3	**54.8**	**46.8**
Nor. value	60 [dB]	50 [dB]	**65 [dB]**	**56 [dB]**

Then an analysis of the expanded uncertainty of measurements: where calculated uncertainty of type A and type B uncertainty for every situation at a confidence level of 95% [3]. The expanded uncertainty (11.2) determined for a confidence level of 95% is due to the noise test scattering measurements considered together with the background noise and the acoustic background noise and uncertainty associated with the measurement hardware used and applied measurement procedure.

$$U_{R,95} = \sqrt{U_{A,95}^2 + U_{B,95}^2} \qquad (11.2)$$

gdzie:

$U_{R,95}$ – expanded uncertainty,
$U_{A,95}$ – Type A uncertainty associated with the projection of the measurement results,
$U_{B,95}$ – Type B uncertainty associated with the equipment and procedure of measurement.

The values of equivalent sound level for the sum of acoustic situations with values of expanded uncertainty at the 95% confidence level ($U_{R,95}$) of the upper and lower deviation are shown in table 11.4.

Table 11.4 Equivalent value of the level of sound of the sum of acoustic situations along with the uncertainty widened (+$U_{R,95}$, - $U_{R,95}$) for test points in the period of the day and the night

Measurment points	2011r. [4]		2012r.	
	Day time $L_{Aeq\ D}$ [dB]	For night time $L_{Aeq\ N}$ [dB]	Day time $L_{Aeq\ D}$ [dB]	For night time $L_{Aeq\ N}$ [dB]
1	**64.2 (1.0;1.0)**	**49.3 (0.9;1.0)**	**65.3 (0.9;0.9)**	**50.1 (0.9;0.9)**
2	**59.0 (0.7;0.8)**	**50.2 (1.0;1.1)**	**59.9 (0.8;0.7)**	**50.7 (0.8;0.8)**
3	**58.0 (0.7;0.7)**	**50.5 (0.9;1.1)**	**59.1 (0.8;0.8)**	**50.7 (0.7;0.8)**
4	**53.2 (0.7;0.7)**	**45.5 (0.9;1.0)**	**53.8 (0.7;0.8)**	**45.8 (0.9;0.9)**
5	**63.1 (0.6;0.7)**	**55.8 (1.0;1.2)**	**64.0 (0.7;0.7)**	**52.3 (0.7;0.8)**
6	**53.8 (0.7;0.7)**	**46.3 (1.0;1.2)**	**54.8 (0.7;0.7)**	**46.8 (0.7;0.8)**
Nor. value	**60 [dB]**	**50 [dB]**	**65 [dB]**	**56 [dB]**

As a result of the preliminary analysis of the obtained measurement results (table 11.1 and 11.2) may be noted that in the fifth step of the gauge closest roadway, measurements of the value of the L_{Aeq} exceeded the limit values (night crossing did not occur). This has happened in every era of measurement and is therefore equivalent values for day, night, and total $L_{Aeq\ D}$ acoustic situations were not exceeded in accordance with the amendment in 2012 of the Minister of Environment of 14 June 2007 on the levels of environmental noise increasing the traffic noise levels allowed from 5 to 10 dB (in 2011 these values were exceeded 4.2 dB $L_{Aeq\ D}$ – table 11.3).

In the fourth and sixth point (table 11.2), which were furthest from the road, recorded the lowest value of the noise level. During the day there were no crossing over the well standardized in 2011 as there were no such levels.

The first measurement point (table 11.1) in each age exceeded the limit value applicable to the $L_{Aeq\ D}$ by up to 9.8 dB (4.2 dB maximum in 2011). In the event of the night crossing occurred in the hours between 22:00 and 23:00, by up to 2.5 dB (0.4 dB maximum in 2011). The equivalent sound level of total listening situations for the night was 50.1 dB, but with the upper deviation ratio of 0.9 dB value does not exceed the limit value (table 11.4).

The second measurement point (table 11.1) limit value for daytime L_{Aeq} were exceeded in parts L_{Aeq} measurements in each age measured in the range between 11:00 and 18:00, and an equivalent level for the sum of acoustic situations $L_{Aeq\ D}$ was 59.9 dB. Given the uncertainty of measurement of sound intensity value at this point is not exceeded (table 11.4). The night-time limits are exceeded between the hours of 22:00 and 23:00, 5:00 and 6:00, but that did not result in a situation that for the sum of acoustic $L_{Aeq\ N}$ exceedance of code (table 11.4). In 2011, the value of $L_{Aeq\ D}$ was 59.0 dB and the $L_{Aeq\ N}$ 50.2 dB).

The third measurement point (table 11.1) for daytime $L_{Aeq\ D}$ in each of the nights of measurement recorded single crossing during the day, but at night time exceeded absent. Given the uncertainty of measurement (table 11.4) the situation for the time of day or night does not change (in the year 2011 the value of $L_{Aeq\ D}$ was 58 dB and the $L_{Aeq\ N}$ 50.5 dB).

11.6 CALCULATIONS OF THE ACOUSTIC SCREEN [4]

The primary objective is to provide an acoustic screen acoustic shadow, the area of which does not reach the source direct acoustic waves. Acoustic shielding can be achieved not only by setting the flat screens, but also other obstacles [1, 2]. Often the passageways where values are exceeded noise emission standard applied acoustic screens. Their effectiveness varies, for example, shows the effectiveness of screening is currently the most common method Maekawy [2].

Typical baffle, which is being built by Polish passageways, the vertical screen height of 5 meters. According to the permissible sound level at al. W. Korfantego to 65 dB for the interval from 6 to 22 and 56 dB from 22 to 6 hours The largest deviation from the norm is 0.3 dB, which occurred in the first measuring point, the effectiveness of screening must reach, including the expanded measurement uncertainty, at least 1 dB.

To check the efficiency of acoustic and acoustic shadow range were calculated using a screen Maekawy vertical height of 5 meters. Dimensions constants that occur in the source system – screen – observer (fig. 11.2) are: H = 5 [m], the height of the screen, and h1 = 1 [m], since roughly the amount emitted is the noise of the vehicles. The distance from the noise source observer is based on the map 30 meters (max. DF) and the acoustic screen 8 feet. The height of the observer will be increased by 1 meter, in the range of from 4 to 10 meters and the other dimensions are calculated in accordance with the method Maekawy.

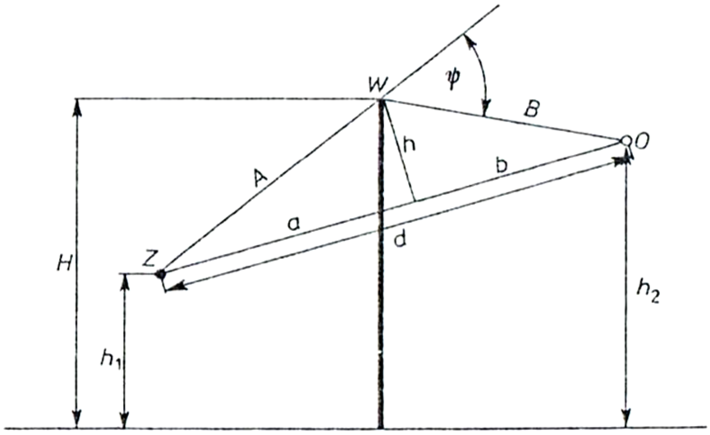

Fig. 11.2 Source system baffle – the observer [1]

The calculation results are shown in table 11.5.

Table 11.5 Dimensions of the agreement source – screen – observer depending of h_2 parameter

Lp.	Fixed dimensions				Par.	Calculated dimensions					
	H	h_1	*odl. ZO*	*odl. od ekr.*	h_2	*A*	*B*	*d*	*h*	*a*	*b*
1	5	1	30	8	4	8.9	22.0	30.1	3.2	8.4	21.8
2	5	1	30	8	5	8.9	22.0	30.3	2.9	8.5	21.8
3	5	1	30	8	6	8.9	22.0	30.4	2.6	8.5	21.9
4	5	1	30	8	7	8.9	22.1	30.6	2.4	8.6	22.0
5	5	1	30	8	8	8.9	22.2	30.8	2.1	8.7	22.1
6	5	1	30	8	9	8.9	22.4	31.0	1.8	8.8	22.3
7	5	1	30	8	10	8.9	22.6	31.3	1.5	8.8	22.5

Based on the calculated size in table 11.5 shielding effectiveness is calculated according to the method Maekawy [2], assuming the wavelength λ = 0.5 m, the results are shown in table 11.6.

Table 11.6 Effectiveness of the shielding of the acoustic screen calculated Meakawy method

Lp.	Parametr	Values calculated		
	h_2	δ	N	ΔL_e [dB]
1	4	0.8	3.3	18.2
2	5	0.7	2.7	17.3
3	6	0.6	2.2	16.5
4	7	0.4	1.8	15.5
5	8	0.3	1.4	14.4
6	9	0.3	1.0	13.1
7	10	0.2	0.7	11.9

The presented results of calculations effectiveness of typical acoustic screen which dominates the Polish passageways that shadow area in this case is sufficient to cover the protection of all blocks of flats 10-storey closest to the road, in the light of the revised in 2012, the Minister of the Environment of June 14, 2007 on the permissible noise levels in an environment of increasing the road traffic noise levels allowed from 5 to 10 dB.

SUMMARY AND CONCLUSIONS

As a result of research and analysis of road noise with the calculation of the expanded measurement uncertainty specified place, where it was exceeded VALUE ONLY normalization and acoustic nuisance at the same time set the site, which is at the level of medium and large in line with the guidelines of the National Institute of Hygiene in Warsaw. You may also find that the obtained results exceed a maximum value of 0.3 dB $L_{Aeq\ D}$ standardized values. Striking is the fact that the value exceeded the standard in 2011 to this point was 4.2 dB, this value even in 2012 increased by another 0.9 dB, in the light of the amendments made in 2012 of the Minister of Environment of 14 June 2007 the permissible noise levels in the environment normalized value was exceeded only by 0.3 dB.

Analyzing the values of equivalent sound level can be clearly stated that the acceptable level $L_{Aeq\ D}$ was exceeded in the first measurement point. The values of equivalent sound level for daytime within the normal range in the other measuring points for the day-time and all measuring points for the night. In 2011, the standardized values were exceeded in the first and fifth measuring point for the season genie and the second, third and fifth for the night. Considering the case of transgression occurring in the first measuring point can be stated that action should be taken to minimize this risk.

The calculation of the effectiveness of a typical acoustic screen that shadow area in this case is sufficient for all floors of apartment blocks located close to the road at al. W. Korfantego. For the analyzed case, it meets the requirements of security to protect the residents of multi-storey buildings against noise from traffic, but you should also consider other means of financial support to minimize noise, even changing the windows to the sound.

According to the amendment in 2012 of the Minister of Environment of 14 June 2007 on the levels of environmental noise for Increasing traffic noise levels allowed from 5 to 10 dB in a formal solution to the issue of noise, inter alia, for this case but also Whether the terms of its impact on the lives and health of people or comforts existence ?

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8. Rozporządzenie Ministra Środowiska z dnia 16 czerwca 2011 r. w sprawie wymagań w zakresie prowadzenia pomiarów poziomów substancji lub energii w środowisku przez zarządzającego drogą, linią kolejową, linią tramwajową, lotniskiem lub portem.
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NOISE EMISSIONS TEST FROM THE COMMUNICATION ROUTE – A CASE STUDY

Abstract: *The publication presents a study on the issue of noise from the communication route al. W. Korfantego in Zabrze in 2012 in aspect of noise nuisance. The results were related to measurements made in 2011, in the context of the amendment of the Minister of Environment of 14 June 2007 on the levels of environmental noise. It also presents the method of calculating noise barriers by Maekawy.*

Key words: *traffic noise, noise studies, noise nuisance*

BADANIA EMISJI HAŁASU Z CIĄGU KOMUNIKACYJNEGO – STUDIUM PRZYPADKU

Streszczenie: *W publikacji przedstawiono badania emisji hałasu z ciągu komunikacyjnego al. W. Korfantego w Zabrzu w roku 2012 w aspekcie uciążliwości akustycznej. Wyniki badań odniesiono do pomiarów wykonanych w 2011 roku w aspekcie nowelizacji Rozporządzenie Ministra Środowiska z dnia 14 czerwca 2007 r. w sprawie dopuszczalnych poziomów hałasu w środowisku. Przedstawiono również obliczenia ekranów akustycznych metodą Maekawy.*

Słowa kluczowe: *hałas, badania hałasu, uciążliwości hałasu*

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