

# Experimental research into the dispersion of railway traffic noise in the environment and its modelling

**Pranas Baltrėnas,**

**Donatas Butkus,**

**Raimondas Grubliauskas**

*Department of Environmental Protection,*

*Vilnius Gediminas Technical University,*

*Saulėtekio 11, LT-10223*

*Vilnius-40, Lithuania*

*E-mail: pbalt@ap.vgtu.lt,*

*butkus@ap.vgtu.lt,*

*raimon@ap.vgtu.lt*

In recent decades, inadequacies between nature and human activities have become one of the most relevant social-economic problems. With the rapid development of industrialisation and urbanisation, the environmental pollution has greatly increased. In the majority of towns and settlements, noise is justly considered as an ecological problem.

The Paneriai Railway Station was selected for the research as one of the most intensive by the number of passing trains. The analysis of the noise level caused by railway traffic near the junction of the Paneriai Railway Station shows that at low frequencies (31.5–250 Hz) the permissible noise level (PNL) was exceeded by 2–5 dB. The findings of research into noise caused by the passing railway transport show that the levels of the equivalent noise exceed by 4–8 dBA the noise levels permissible in living territories.

The level of noise caused by passing trains is exceeded in the frequency range of 125–4000 Hz. The permissible noise level is exceeded by about 8 dB at the frequency of 500 Hz and 7 dB at the frequency of 1000 Hz.

The generated model of noise dispersion from the railway traffic to the living environment helped offer the noise reduction walls as a means of improving the living environment.

**Key words:** railway traffic noise, noise modelling, permissible noise level, noise reduction walls

## INTRODUCTION

French specialists consider noise caused by railway traffic as the second issue by importance after the problem of ensuring the safe traffic of high-speed trains. For the Japanese, this is the most important problem when increasing train driving speeds. With an increase in driving speeds, the durability of trains, driving comfort as well as the harmony between railways and the surrounding environment are enhanced. To improve the driving comfort in new trains special shock-absorbers are used, noise insulation hollows are filled with noise-insulating materials, to reduce noise caused by engines and other electric equipment special insulating bipolar transistors are applied in electric circuits, to reduce noise and minimize pressure problems in tunnels aerodynamic characteristics of trains are advanced by designing new forms of trains with more even lateral surfaces (Obelenis, Gedgaudienė, 2003).

The level of noise caused by railway traffic depends on the moving part of the driving mechanism of a train and auxiliary installations. Diesel-powered locomotives mainly cause noise by forward and backward moving parts and turbochargers, while the noise of the wheel–rail contact is predominant when electric or passenger trains are moving. The degree of noise caused by a passing train is for the most part influenced by the noise caused by its rolling (the noise of contact of its wheels and rails), which is the speed function. The noise of rolling is caused by the general roughness of a wheel and

railroad and the dynamic behaviour of the railroad and the wheel system. The level of noise caused by a railway depends on the conditions of relief it is spreading along (Vasarevičius, Graudinytė, 2004).

Noise aroused by rolling-stocks can be reduced by employing a large variety of means: by modernizing the rolling-stocks or acquiring more modern ones causing less noise, restoring or modernizing railroads, repairing railway cars and engines and modernizing diesel locomotives (Jonaitis, 2006). Apart from that, technical means are employed: replacement of metal shoes of carriage brakes with composite ones, installation of lubricating systems of wheel rims of locomotives, polishing of rails, turning of car and diesel-powered locomotive wheels, welding of rails to eliminate joints, etc. (Graudinytė, 2002).

The most cardinal way of dealing with the increasing dissatisfaction with noise and vibration caused by railway traffic is to forbid the construction of residential buildings in the areas where it is impossible to ensure a noiseless living environment (Bazaras, 1998).

A wide range of measures can be employed to reduce the effects of noise caused by railway traffic on the living environment:

- reduction of the level of noise emitted by means of transport as a source of noise;
- employment of screens;
- installation of railroads in tunnels;
- usage of special windows containing glass packages;
- usage of noise screens (Klibavičius, 1998).

Where railways are stretching along the areas that can be identified with a rural environment, planted noise reduction guards would perfectly suit the case. It might be complicated to integrate a noise reduction screen into an open rural landscape so that it would not disturb the visual environment (Sužiedėlytė-Visockienė, 2006).

The role of screens can be performed by:

- biological protection – protective bands of trees or shrubs;
- special structures occasionally used by people;
- formation of a street environment relief by using excavations, soil embankments, planted areas, structures;
- structures, screens, acoustic walls.

Noise exerts a great direct effect on human health and the quality of the living and recreational environment. Traffic, as a dynamic source of noise, has an especially big adverse effect on the environment. The effect of noise on humans can be divided into two groups:

- the effect of noise on hearing;
- the effect of noise on the whole human system and activities (Baubinas, Vainauskas, 1998).

When the waves of acoustic noise reach human tissues, especially the organs of hearing, they periodically press them and make them vibrate. The nervous system transfers these vibrations to respective centres in the brain. When exposed to a long-lasting, even if not very intensive, noise the hearing gets tired, i. e. a temporary worsening of the hearing sensitivity occurs, which disappears after spending some time in a quiet environment. A long-term exposure to a very intensive noise damages the nervous apparatus. These changes most often start in the cochlear apparatus due to disorders in the central and vegetative nervous system, which results in headaches, worsened memory, sleeping disorders and development of neuroses. These disorders occur prior to the worsening of hearing.

Noise accounts for 30 percent of premature ageing. When exposed to a big noise, a person cannot concentrate his thoughts, gets tired quickly and consumes more energy. Noise worsens hygienic working conditions and reduces labour efficiency (Mačiūnas ir kt., 1999).

Thus, noise is an environmental factor harmful to health, causing specific and non-specific pathological changes in various systems of the human organism. It is a significant risk factor for developing hearing, nervous, cardiovascular and digestive tract diseases (Pilipavičiūtė, Bakas, 1998).

It is difficult to establish and forecast the effect of noise on animals. This depends on the animal's breed, stage of life, season, ecological conditions, reproduction capacity, lifestyle as well as types of noise. In researchers' opinion, the effect of noise on animals can be evaluated applying the method of assessing the effect of noise on humans, i. e. to evaluate the effect of noise on animals at the equivalent level  $Leq$ . Birds and mammals are distinguished by a high sensitivity to noise. As a rule, big mammals (elephants, bears, dolphins) are more sensitive to low-frequency sound signals as well as ultrahigh frequency sounds which a human does not hear at all. Small mammals (mice, hares, bats) are better to feel weak sounds and vibration signals. The sensitivity distance of birds to humans and unknown objects is 500 m. When birds get accustomed to the environment, the distance of their sensitivity becomes shorter (Januškis, 1990).

## METHODS

The study into noise caused by railway traffic was performed in measuring places selected nearby Lithuania's railway stations.

The aim of the study was to set the levels of noise caused by passing railway vehicles during the daytime in a dwelling territory located in a close proximity to railroads and to compare them with the current legislation and with CadnaA noise pollution modelling software to find and propose a noise reduction barrier.

The Paneriai Railway Station was selected for this research. It is one of the most intensive stations by the number of trains passing by it. Around 60 passenger and around 30 goods trains pass this station per day. This is preconditioned by the fact that Vilnius and Kaunas regions are the most important ones in passenger transport, and Paneriai is located between these regions. Apart from that, the main flows of transit cargoes via branches B and D of the international transport corridor IX in the direction of Kaliningrad and Klaipėda are realized through the Paneriai Railway Station. Furthermore, it services cargo trains going between the East and the West and to and from Kaliningrad Region, a geographically separate region of Russia.

Measurements of noise caused by railway traffic were performed at randomly selected places. The measuring places were selected taking into consideration the planting and build-up of a location as well as its distance from the railroad. Having in mind the processes of screening of residential houses or buildings of other purposes as well as reflections behind them, measurements were taken in front of and between the buildings. Taking into consideration the capacity of planted areas to absorb and reflect acoustic waves, the measuring places were selected in the areas planted with trees and in a close proximity to forested territories. Two places located at a 100-meter distance from the railway were selected for measurements. The levels of noise in these measuring places were recorded in order to determine noise levels in the sanitary protection area (SPA) at a 100-meter distance from the railway.

To investigate the dispersion of railway-related noise near by the Paneriai Railway Station, four measuring places were selected (Fig. 1).

The measuring place 1.1 is located at a 100-meter distance from the railway, close to a forested territory. On the right of the measuring place there is a large space which is obscured from the railway only by house No. 24 on Agrastų Street. A forest stretches on the left of the measuring place. Tall trees are growing behind the house. The distinguishing feature of this measuring place is that planted areas and houses have a major impact on the dispersion of railway-related noise.

The railway-related noise measuring place 1.2 was selected by the 2-storeyed house No. 24 on Agrastų Street. Nine railroads pass by the measuring place. On the right of this measuring place there are a platform and a pedestrian passage over the rails. Behind the measuring place there are several dwelling houses. The distance from the measuring place to the rails is 45 m. In front of the measuring place there are no obstacles that could influence the dispersion of noise caused by railway traffic.

The measuring place 1.3 was selected in a residential territory by the house No. 32 on Vilijos Street. This is a 2-storeyed wooden house. Its windows are wooden and open on the rails.

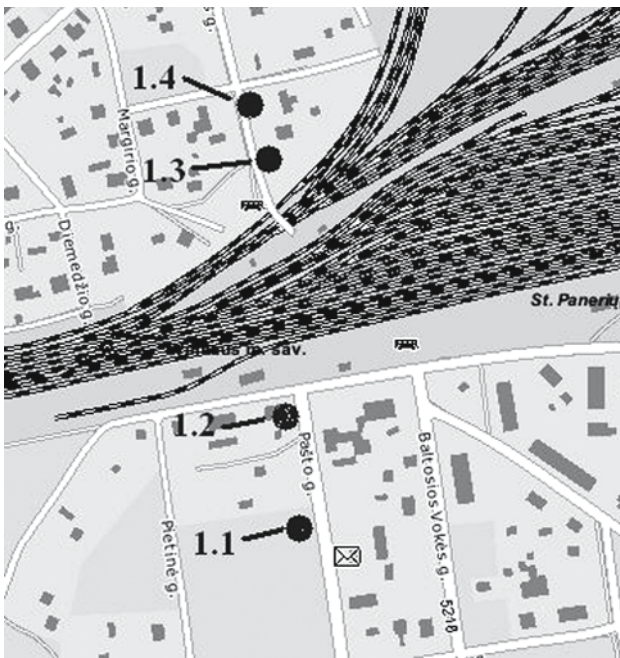


Fig. 1. The layout of places to measure noise caused by the Paneriai Railway Station

In front of the measuring place there is an open space with several trees. On the right of the measuring place there is a passage through the rails. There are several wooden structures followed by tall trees behind the house. The distance from the measuring place to the rails is 40 m.

The measuring place 1.4 is at a 100-meter distance from the railway, behind the house No. 32 on Vilijos Street. From the left it is obscured with trees and structures. There are no obstacles to prevent the dispersion of the noise wave in front of the measuring place.

The levels of noise are evaluated by comparing the measuring values with the permissible noise level values set in the Lithuanian hygiene standard HN 33:2007. In a residential territory, during the daytime the maximum noise level cannot exceed 70 dBA, in the evening 65 dBA and at night 60 dBA. In a residential territory, the equivalent noise level cannot exceed 65 dBA, in the evening 60 dBA, at night 55 dBA.

Prior to making noise level measurements, the meteorological conditions were determined: the relative air humidity,

air temperature and wind speed. Measurements were not taken when there was snow, rain, fog or the wind speed was higher than 5 m/s. When the wind speed was 5 m/s, the microphone was covered with a special screen. Prior to and after taking measurements, the device was calibrated according to the manufacturer's instruction. If the calibration results differed by more than 2 dB, noise measurements were repeated.

In the territories nearby dwelling houses, the noise was measured in a place at a distance of 1 or 2 m from the house wall, at the height of 1.5 m from the surface at a distance of at least 0.5 m from a person taking the measurements by turning the microphone towards the source of noise.

The noise caused by railway traffic was measured when the microphone was in a perpendicular position to the railway line, and the measuring was started when the train crossed the line of alignment. The measuring was completed when the last car of a train crossed the line of alignment. The measured values were the equivalent and maximum noise levels (dBA) and noise pressure levels (dB).

The Bruel & Kjaer mediator 2260 noise and vibration meter was used for noise measuring. When metering noise with the Bruel & Kjaer mediator 2260, a relative measuring error is  $\pm 1.5\%$ . This is one of the latest instruments of this company. This meter can measure the parameters of an equivalent and broadband noise and has a supplementary external device intended for measuring vibration. The device records noise within the frequency range of 6.3 Hz – 20 kHz. It can also be used to measure the efficient noise level defined as characteristics A, B or C or within separate octaves that are separated by standardized filters. When measuring the frequency spectrum of noise, the lowest frequency is recorded first and further measurements are performed for all values of frequencies (31.5–8000 Hz).

RESULTS AND DISCUSSION

Measurements of the noise levels of an electric passenger train and when passenger trains were passing measuring place 1.1 showed no excessive values (Fig. 2). No excessive noise level was found in the measuring place 1.1 because residential houses and separate trees in front of the measuring place are sufficient obstacles to suppress the dispersion of noise.

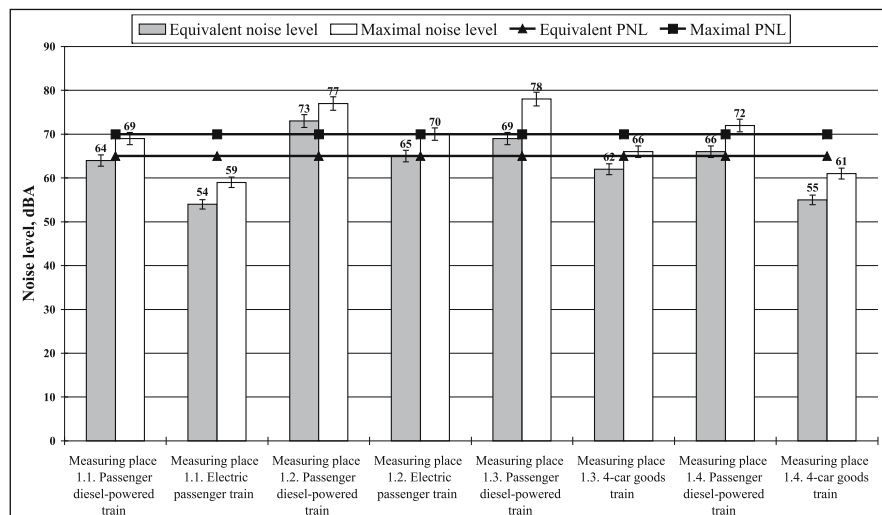


Fig. 2. The equivalent and maximum noise levels caused by passing trains at the measuring places of the Paneriai Railway Station in the daytime

The levels of noise caused by passing passenger trains were measured in the measuring place 1.2. When passenger diesel-powered trains were passing by the place, the permissible equivalent noise level (PNL) was exceeded by 8 dBA, and it was equal to the PNL when a passenger electric train was passing by it. Measurements of the maximum noise levels caused by passing trains showed that the passenger diesel-powered train exceeded the PNL by 7 dBA, while the noise caused by the passenger electric train was equal to the permissible maximum noise level, i. e. 70 dBA. Another thing that mattered was that the distance from the measuring place to the rails was 45 m and nothing obstructed the dispersion of noise. In addition, this was influenced by the fact that the passenger diesel train passed by the station at a high speed and did not stop there.

The noise level caused by passing freight and passenger trains was measured in the measuring place 1.3. In this place, the permissible equivalent noise level was not exceeded when a 4-car goods train was slowly passing by the place, and it was ex-

ceeded by 4 dBA in the case of a passenger diesel-powered train. The maximum permissible noise level was exceeded by 8 dBA when a passenger diesel-powered train passed by the place at a high speed without stopping.

The noise levels caused by a passing passenger diesel-powered train and a 4-car goods train were measured in the measuring place 1.4. In this place, only the exceeded equivalent and maximum noise levels caused by a passing passenger diesel-powered train were recorded. In this measuring place, the permissible equivalent noise level was exceeded by 1 dBA and the maximum one by 2 dBA. As compared to the measuring place 1.3, the excess of PNL was smaller because this measuring place was at a distance of 100 m from the rails and there were no obstacles preventing the dispersion of sound. Also, the passenger train passed by the measuring place at a high speed without stopping.

In order to analyse more extensively the dispersion of noise caused by railway traffic, Fig. 3 presents the frequency characteristics of noise caused by railway traffic (Table).

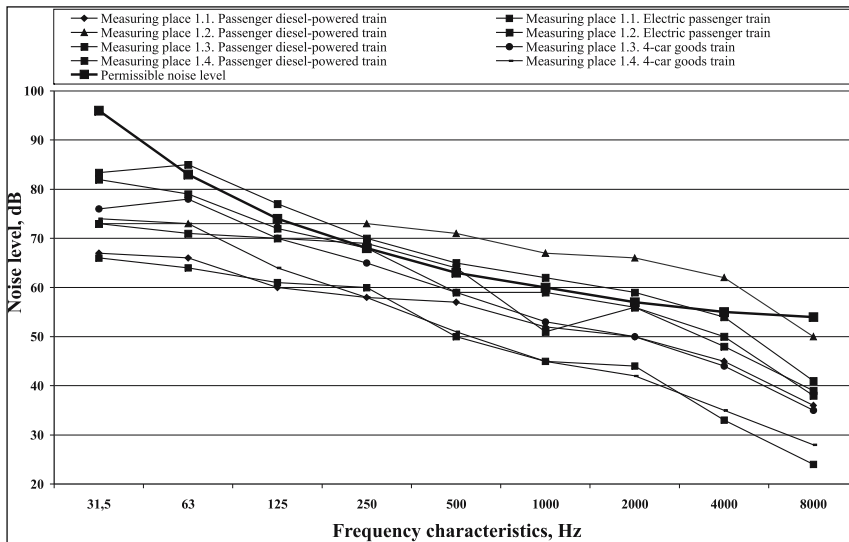


Fig. 3. Frequency characteristics of the dispersion of noise caused by passing trains at the measuring places of the Paneriai Railway Station in the daytime

Table. Data on noise caused by railway traffic

	Equivalent noise level	Maximal noise level	Frequency characteristics, Hz								
			31,5	63	125	250	500	1000	2000	4000	8000
Measuring place 1.1. Passenger diesel-powered train	64	69	67	66	60	58	57	52	50	45	36
Measuring place 1.1. Electric passenger train	54	59	66	64	61	60	50	45	44	33	24
Measuring place 1.2. Passenger diesel-powered train	73	77	73	73	73	73	71	67	66	62	50
Measuring place 1.2. Electric passenger train	65	70	73	71	70	69	64	51	56	50	38
Measuring place 1.3. Passenger diesel-powered train	69	78	83	85	77	70	65	62	59	54	41
Measuring place 1.3. 4-car goods train	62	66	76	78	70	65	59	53	50	44	35
Measuring place 1.4. Passenger diesel-powered train	66	72	82	79	72	68	59	59	56	48	39
Measuring place 1.4. 4-car goods train	55	61	74	73	64	58	51	45	42	35	28
Permissible noise level	65	70	96	83	74	68	63	60	57	55	54

The level of noise caused by railway traffic in the measuring places 1.1 and 1.4 (i. e. at a 100 m distance from the railway) shows that the level of noise caused by the train did not exceed the permissible noise level under low, medium or high frequencies.

In the measuring place 1.2, the level of noise caused by a passenger diesel-powered train exceeded the maximum level in the frequency range of 250–4000 Hz. The highest excess of the permissible noise levels (7–9 dB) was recorded in the frequency range of 500–4000 Hz. The level of noise caused by a passenger electric train was by 1 dB higher than the permissible one in the frequency range of 250–500 Hz.

In the measuring place 1.3, the permissible noise level was exceeded by 2–3 dB in the frequency range of 63–2000 Hz in the case of a passenger diesel-powered train. The level of noise caused by a passing 4-car goods train did not exceed the permissible noise level under low, medium or high frequencies.

As maintained by researchers, the excess levels of noise caused by railway traffic at the frequencies up to 400 Hz are influenced by the railway sleepers. The rails and their condition influence the levels of noise in the frequency range of 400–2000 Hz, while the noise level at high frequencies (over 2000 Hz) mainly depends on the condition of the train's wheels (Vér, Beranek, 2006).

A long-time exposure of humans to a high frequency (over 1000 Hz) noise whose intensity increases 80 dB is detrimental to hearing. The study performed at the Paneriai Railway Station showed that here the levels of high frequency noise vary from 45 to 65 dB.

## MODELLING

The simplest way to evaluate the acoustic pollution of the environment is to measure the levels of the environmental noise sound pressure. However, the scope of application of the measuring method is rather narrow. There are many reasons why the application of measuring methods is impossible or economically unsound:

- situations when the level of the background environment noise is close to the noise of the source under study;
- while forecasting environmental noise levels prior to implementing environmental changes;
- while comparing the alternatives of dealing with ambient noise reduction problems;
- measurements in places that are difficult to access.

To model and forecast the dispersion of noise, CadnaA (Computer Aided Noise Abatement) software was used. It is a software intended for the computation, representation, evaluation and forecasting of the level of noise and acoustic air pollution. This software assesses a number of noise sources such as industrial plants, shops with parking lots, streets and railways. It can assess the noise of the whole city at the same time. The computation results include the level of noise caused by railway transport flows at different points.

This software evaluates in detail the relief of a territory, the build-up of a location, acoustic qualities of buildings, transport flows, maximum speeds, meteorological conditions, etc.

This program can evaluate and describe up to 16 million of objects. Noise is rated according to the EU Directives. The ob-

tained results of noise dispersion can be represented in a three-dimensional image. Another option is noise mapping.

For some special sources, such as road and railway transport or airports, the amount of acoustic emissions is separated from the technical parameters.

CadnaA records the levels of noise at any points and places on horizontal or vertical planes or on the façades of buildings. For some special sources, such as motor and railway traffic, airports, acoustic emissions are obtained based on technical parameters. They can be selected from a number of national and international standards.

In the CadnaA programme, noise maps are generated by specifying noise sources allocated in a locality. They may be on a particular or absolute height. The noise maps may be developed by indicating the required step.

The assessment of noise emissions with CadnaA software is performed following the requirements of the national and international legislation, i. e. 2002/49/EC (Directive relating to the assessment and management of environmental noise).

The Junction of the Paneriai Railway Station was selected for modelling because this is one of the most intensive railway stations in Lithuania by the number of trains passing by it.

The dispersion of noise in the Paneriai Railway Station's junction was simulated with the aim to assess the impact of current noise sources on the living territory of the Paneriai Railway Station.

Based on the existing situation, a model of the Paneriai Railway Station's junction was generated considering the population and the position of the location. Dwelling houses are at a distance of about 20–40 m from the railway; consequently, they are in the sanitary protective area (SPA) of the railway whose width is 100 m.

When modelling the Paneriai Railway Station's junction it was assumed that the relief of the station is conditionally even, one train passes by it at a time, and the level of noise caused by motor traffic which could increase the level of noise of the Paneriai Railway Station living environment was not assessed. We assessed only the noise caused by railway traffic.

The dispersion of noise caused by passing trains is nearly evenly distributed in all directions. Somewhat further from the train the level of noise decreases. Besides, it is easy to notice that the level of noise decreases behind the buildings. This is an example how buildings perform the function of the noise screen.

The dispersion of noise caused by sources of noise (trains) in the junction of the Paneriai Railway Station is shown in Fig. 4. These models are formed by evaluating the level of noise caused by a passenger train (4a – when a passenger train goes along the 2nd railroad; 4b – when a passenger train goes along the 5th railroad). The quantities given in Fig. 4 mean the equivalent noise level in dBA in that place. The dispersion of noise caused by railway traffic was modelled when trains moved on the 2nd and 5th railroads, because the measurement had been performed when trains were moving on the 2nd or 5th railroad.

As Fig. 4 shows, the levels of noise by the living territory (to the south from the railway line) are highest when a train goes along the 2nd railroad (74–77 dBA) and when the train goes along the 5th railroad (73–75 dBA), the permissible noise level

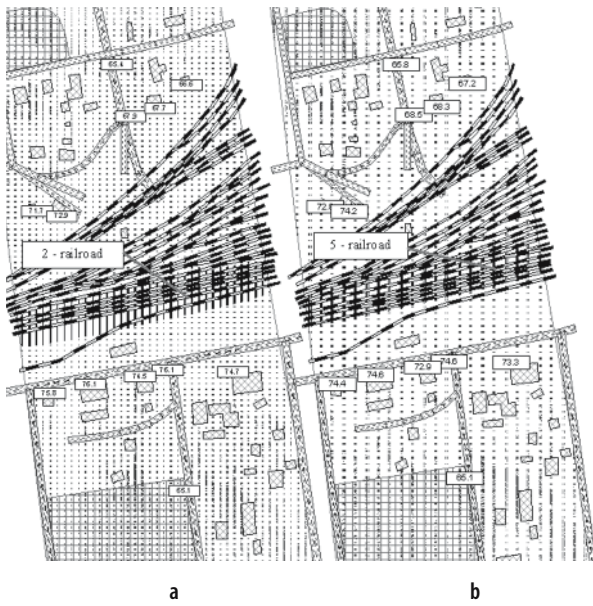


Fig. 4. Dispersion of noise caused by a passenger train: a) when going along the 2nd railroad; b) when going along the 5th railroad

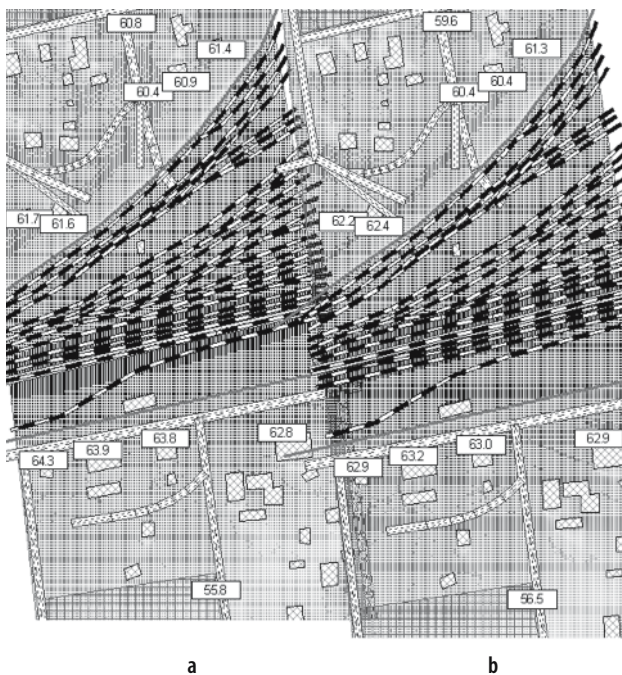


Fig. 5. Dispersion of noise caused by a passenger train when a noise reduction wall is installed: a) when going by the 2nd railroad; b) when going by the 5th railroad

being 65 dBA. Consequently, the permissible level of noise on this side of the railway line is exceeded by 8–12 dBA. In the living territory to the north of the railway line, the level of noise was lower and reached 66–73 dBA near dwelling houses when a train went along the 2nd railroad, and 67–75 dBA when the train went along the 5th railroad. Thus, in this living territory the permissible level of noise is exceeded by 1–10 dBA.

As the presented modelling of the dispersion of noise caused by railway traffic shows, it is necessary to search for rational ways of reducing the noise level to the permissible standards to avoid adverse effects on human health.

The present study shows that the easiest way to improve the situation is the installation of noise abatement walls along the railway line and thus to suppress the noise caused by passing trains.

Figure 5 presents the situation when noise is reduced by installing noise abatement walls. Figure 5a shows the situations when a passenger train goes along the 2nd railroad and noise abatement walls are installed along the rails. Noise reduction walls of different height starting from 1 m and up to the height the noise level in the living environment meets the permissible one were selected for the modelling. To improve the situation in the territory to the south of the railway line when the passing train is a passenger diesel-powered 16-car train, a 6-meter high noise reduction wall would be necessary, and it would reduce the noise level in the living environment to 63–64 dBA. To reduce the noise in the territory to the north of the railway line to the permissible level, a 6-meter high noise reduction wall should be installed, and then the noise level would reach 61–62 dBA. The noise reduction wall is represented by a red line.

Figure 5b shows the situation when the passenger train goes along the 5th railroad. Like in the previously described situation, the aim was to determine the optimum height of the noise reduction wall that would ensure the permissible noise level in the living environment around the houses. Analysis of the territory to the south of the railway line when the train goes along the 5th railroad shows that it would be enough to install a 6-meter high noise reduction wall which would allow ensuring a proper living environment. A 6-meter high noise reduction wall would be necessary in the territory to the north of the railway line to reduce the noise level to 61–63 dBA.

Based on the modelling of dispersion of the noise caused by a passenger train, the proposal can be made to install noise reduction walls by the railway line, which would reduce the level of noise to the permissible standards. To improve the situation in the territory to the south of the railway line, a 6-meter high noise reduction wall would be necessary, and to improve the living environment in the territory to the north of the railway line a 6-meter high noise reduction wall would be required.

To improve the living environment of the Paneriai Railway Station, implementation of these proposals is essential because health is the main human treasure.

## CONCLUSIONS

1. A research into the equivalent noise caused by railway traffic in the settlement located by the junction of the Paneriai Railway Station shows that the permissible noise level there is exceeded by about 8 dBA. The permissible noise level of 65 dBA is exceeded in the living territory when nearly all types of trains pass by the station, except for the measuring places at a distance of 100 m from the rails.

2. The level of noise caused by passing trains is exceeded in the frequency range of 125–4000 Hz. The permissible noise level is exceeded by about 8 dB at the frequency of 500 Hz and 7 dB at the frequency of 1000 Hz.

3. The generated model of noise dispersion from the railway traffic to the living environment helped to establish the impact of the noise wall on the territories near the railway station. Two

noise reduction walls 6 m high, installed on both sides of the railway, would allow reducing the level of noise caused by railway traffic in the living territory to the permissible levels.

Received 26 March 2007

Accepted 3 March 2008

## References

1. Baubinas A., Vainauskas S. 1998. Gyvenamosios aplinkos įtaka moksleivių sveikatai. *Aplinkos inžinerija*. T. 6. Nr. 1. P. 4–8.
2. Bazaras J. 1998. Transporto jėgos įrenginių vidinio triukšmo modeliavimo problemos. *Transport*. Vilnius: Technika. Vol. 21. No. 1. P. 19–24.
3. Januškis V. 1990. Gamta ir mes. Vilnius: Mokslas. P. 15–16.
4. Jonaitis J. 2006. Ribinio traukinio važiavimo geležinkelio linijos atkarpa parametrų nustatymas. *Transport*. Vilnius: Technika. Vol. 21. No. 2. P. 123–130.
5. Jonaitis J., Butkevičius J. 2005. Geležinkelio Rail Baltica tiesimo per Lietuvą galimybių tyrimas. *Transport*. Vilnius: Technika. T. 20. Nr. 5. P. 204–213.
6. Graudinytė J. 2002. Geležinkelio transporto triukšmo lygio įvertinimas skirtingomis reljefo sąlygomis. *Proceedings of the 5th Conference of Lithuanian Young Scientists* „Lietuva be mokslo – Lietuva be ateities“, held in Vilnius on 1 03 2002. Vilnius: Technika. P. 233–240.
7. Klibavičius A. 1998. Transporto neigiamo poveikio aplinkai įvertinimas. Vilnius: Technika. 40 p.
8. Mačiūnas E., Juozulynas A., Genytė L. 1999. Triukšmo įtaka žmonių sergamumui. *Sveikatos aplinka*. Nr. 3. P. 46–48.
9. Obelenis V., Gedgaudienė D. 2003. Autotransporto darbuotojų profesinių ir neprofesinių rizikos veiksnių bei sveikatos tyrimas. *Transport*. Vilnius: Technika. T. 18. Nr. 4. P. 189–192.
10. Pilipavičiūtė J., Bakas A. 1998. Transporto taršos neigiama įtaka gyvenamajai aplinkai. *Aplinkos inžinerija*. Vilnius: Technika. P. 133–138.
11. Sužiedelytė-Visockienė J. 2006. Geležinkelio ruožo topografinio plano atnaujinimo technologijos tobulinimas. *Transport*. Vilnius: Technika. T. 21. Nr. 2. P. 119–122.
12. Vasarevičius S., Graudinytė J. 2004. Investigation and evaluation of noise level at motorway and railway crossings. *Journal of Environmental Engineering and Landscape Management*. Vol. XII. Annex I. P. 19–24.
13. Vér I., Beranek L. 2006. *Noise and Vibration Control Engineering: Principles and Applications*. Wiley-Interscience. 966 p.
14. Žeromskas R. 1998. Lietuvos kelių transporto svarbiausios aplinkosauginės charakteristikos. *Aplinkos inžinerija*. T. 6. Nr. 4. P. 140–145.

Pranas Baltrėnas, Donatas Butkus, Raimondas Grubliauskas

## GELEŽINKELIO TRANSPORTO TRIUKŠMO SKLaidOS APLINKOJE EKSPERIMENTINIAI TYRIMAI BEI MODELIAVIMAS

### Santrauka

Pastaraisiais dešimtmečiais prieštaravimai tarp žmogaus veiklos ir gamtos tapo viena aktualiausių socialinių ekonominių problemų. Sparčiai plėtojant industrializaciją ir urbanizaciją padidėjo aplinkos užterštumo mastai. Daugelyje miestų ir gyvenviečių triukšmas pagrįstai yra laikomas viena svarbiausių ekologinių problemų.

Triukšmo tyrimams parinkta Panerių geležinkelio stotis, kuri, pagal ją pravažiuojančių traukinių skaičių, yra viena intensyviausių šalyje. Prie Panerių geležinkelio stoties mazgo išmatuotas geležinkelio transporto keliamo triukšmo lygis parodė, kad, esant žemiems dažniams (31,5–250 Hz), leistinas triukšmo lygis viršijamas 2–5 dB. Pravažiuojusių traukinių keliamo triukšmo lygis viršijamas 125–4000 Hz dažnių diapazone. Iki 8 dB leistinas triukšmo lygis viršijamas esant 500 Hz dažniui, iki 7 dB – esant 1000 Hz dažniui. Atliktų pravažiuojančio geležinkelio transporto sukeliama triukšmo tyrimų rezultatai rodo, kad ekvivalentinio triukšmo lygiai 4–8 dBA viršija gyvenamosiose teritorijose leistinus triukšmo lygius.

Sukurtu geležinkelio transporto triukšmo sklaidos į gyvenamąją aplinką nustatymo modeliu pasiūlyta gerovę tobulinanti priemonė – geležinkelio transporto keliamo triukšmo sklaidą mažinančios sienelės.

**Raktažodžiai:** geležinkelio transporto triukšmas, triukšmo sklaidos modeliavimas, leistinas triukšmo lygis, triukšmo sklaidą mažinanti sienelė