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RESEARCH ON MOTOR TRANSPORT PRODUCED NOISE ON GRAVEL AND ASPHALT ROADS

Linas Leipus[1], Donatas Butkus[2], Tomas Januševičius[3]

Dept of Enviroment Protection, Vilnius Gediminas Technical University,
Saulėtekio al. 11, 10223 Vilnius, Lithuania
E-mails: [1]*Linas.Leipus@vgtu.lt*; [2]*butkus@vgtu.lt*; [3]*jtomas@vgtu.lt*

Abstract. Vehicles in motion on roads are the main source of noise in the environment. The noise in a car is created by structural noises from car construction, originated from vibrations in an engine, cabin, silencer, wheels and tires. Traffic noise flow depends on its intensity, motion speed, flow composition and extent, quality of the road pavement and build-up of the area along the road. This paper contains research on motor transport produced noise levels on roads of regional significance with gravel and asphalt pavement in Molėtai district. The level of motor transport produced noise was measured in wintertime and summertime at the chosen typical locations considering the nature of the asphalt and gravel road pavement and different landscape morphology forests, topography roughness, open area, upslope, downslope, etc. Also, research of noise level dependence on car speed was performed from 50 km/h to 70 km/h. It was determined during the study that noise level produced by a car moving at a speed of 50 km/h on a road with gravel pavement is higher by 4 dBA than that on a road with asphalt pavement. Upon moving away from the noise source by 50 m, the level of noise decreases by 12 dBA in woodland open areas and by 16 dBA. As car speed increases from 40 km/h to 50 km/h in wintertime, the level of noise rises by 2 dBA. In summertime, as car speed increases from 50 km/h to 70 km/h, the noise level rises by 5 dBA. These differences are due to the presence of ice and snow on the road in winter. Noise depends on physical properties of tires, type of pavement, car vibrations and in particular on pavement roughness.

Keywords: motor transport, noise level, max noise level, reciprocal noise level, gravel road, asphalt pavement (AP).

1. Introduction

As industry develops, cities grow and the number of vehicles increases, zones of acoustic discomfort also expand increasingly. Skrodenis *et al.* (2009) note in their paper that people are constantly affected by noise produced by machines, equipment and devices. Motor transport is the main source of noise in cities and villages. The noise carried from streets, roads and highways forms a part of 80% of athmospheric pollution (Grubliauskas, Butkus 2009). The acoustic pollution produced by all types of vehicles occurs as noise and vibration (Topila *et al.* 2000).

Nowadays, noise has become a common problem, covering all areas of people's life and work. The harm of noise must be evaluated in pathophysiological, economical and sociological aspects and in accordance with the latest scientific achievements (Bazaras *et al.* 2008; Paslawski 2009; Willich *et al.* 2006).

Various studies confirmed the influence of noise on cardiac infarct risk at places such as work and residence (Zavadskas *et al.* 2007a; b).

Research works carried out in Europe showed that almost 25% of population is annoyed by noise produced by vehicles. The noisiest vehicles are trucks, buses, sports cars and motorbikes (Oškinis *et al.* 2004). During the research performed in the USA, it was determined that the noise level produced by heavy vehicles moving at a speed of 100 km per hour had reached a value of 87 dBA, medium vehicles – 83 dBA and light vehicles – 77 dBA.

On 25 June 2002, the European Parliament and the Council adopted *Directive 2002/49/EC On Assessment and Management of Environmental Noise.* This is the first document in Europe which seeks to legally regulate environmental noise (Nemaniūtė 2007).

Vehicle produced noise on roads is mostly influenced by the following factors: vehicle traffic intensity and driving speed, its change and reduction of friction between wheels and road (Baltrėnas *et al.* 2007; Butkus *et al.* 2008; Vaiškūnaitė *et al.* 2009).

The main cause of the increased noise in streets is a high number of old and technically badly-maintained cars. During the last ten years the transport flow in Lithuania has increased 2.4 times. Because of this, a number of traffic accidents have also increased. The drivers experience longer queues and time losses at junctions (Antov *et al.*

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2009). As a result, environment pollution with exhaust fumes, and traffic noise has increased considerably (Jonasson 2007; Kapski *et al.* 2008).

A major part of Lithuania's network of regional and local roads is comprised of roads with gravel and roads with worn-out AP. Technical condition of roads is the worst where the intensity of traffic is growing constantly and the road pavement is not protecting the road structure from the traffic loads and impact of weather conditions. Cars driving on roads of bad condition raise dust and produce noise and this negatively impacts the business and residential zones in regions (Gražulevičienė *et al.* 2004). Rutted asphalt roads not only worsen driving quality and increase dustiness but also create additional noise. To reduce rut formation Radziszewski (2007) in his paper recommends using asphalt mixture and binder modification effective for improving asphalt properties. Laurinavičius and Oginskas (2006) in their work indicate causes of rut formation and presents recommendations on fighting it.

Noise has a negative impact on our body although we do not feel it. The reaction of each individual to noise is different, however the body is under constant stress (Levine *et al.* 1998; Malinauskienė *et al.* 2004; Passchier, V. W., Passchier, W. F. 2000).

With the purpose of reducing this impact the Gravel Road Paving Programme has been implemented in Lithuania since 2004. First of all the roads passing through villages are paved, then the roads with higher traffic intensity and gravel roads connecting larger villages with the network of asphalt roads. Building of bypasses and paving of gravel roads are highly significant measures for air quality improvement. To reduce motor transport risks to human health it is planned not to exceed the noise level of 65 decibels on the newly built and reconstructed roads in living environments, to reduce the number of traffic accidents and to inform the public of potential health impact (Miškinis 2006).

An alternative to road noise reduction without road paving is the erection of noise absorbing or reflecting walls along the roads (Grubliauskas, Butkus 2009; Ishizuka, Fujiwara 2004; Vaišis, Januševičius 2008).

The objective of the research is to make an analysis and to compare the levels of motor transport produced noise on the roads of regional significance with asphalt and gravel pavement in Molėtai district. The measurements were taken in wintertime and summertime, when there is difference in traffic intensity and also in driving and climate conditions.

2. Noise measurement technique

The nature of noise is determined prior to the measurement. Motor transport noise is variable dependent on time of the day. Noise produced by motor transport flow is constituted of the noise produced by single cars. Variable noise is noise with variation higher than 5 dBA and constantly changing, intermitting or pulsating and it is assessed by the reciprocal and max sound levels as it is indicated in the document *LST ISO 1996-1:2005 Akustika. Aplinkos triukšmo aprašymas, matavimas ir įvertinimas. 1 dalis. Pagrindiniai dydžiai ir įvertinimo tvarka* (*Acoustics. Description, Measurement and Assessment of Environmental Noise. Part 1: Basic Quantities and Assessment Procedures* (*idt ISO 1996-1:2003*)).

The Bruel and Kjaer 2260 noise and vibration meter was used to measure the reciprocal and max sound levels. The relative error of this meter is ±1.5%. The Bruel and Kjaer 2260 meter is a state-of-the-art first class sound level meter and sound analyser. This mobile device is suitable for the required measurements and full analysis of measured data when performing the research of noise in living environments and workplaces.

During the measurement the microphone of the noise meter is held at a height of 1.2–1.5 m and not less than 0.5 m away from the person who is performing the measurement and is also pointed to the noise source.

Measuring conditions shall conform to certain requirements: measurement shall not be performed when it is snowing or raining or wind speed is exceeding 5 m/s. In the event that the wind speed is 5 m/s or more, the microphone shall be covered with a special screen. Also other meteorological conditions shall be recorded: wind direction, air temperature, pressure and humidity. All measuring conditions met the current equirements.

The measurement of vehicle produced noise at the chosen location was performed (by LST ISO 1996 – 2 standart) with two microphones at the same time:

– at point A (at a distance of 7.5 m from the axial line of the trajectory of a moving car) and point B (at a distance of 20 m);
– at point A (at a distance of 7.5 m from the axial line of the trajectory of a moving car) and point C (at a distance of 50 m) (Fig. 1).

The measurements of car produced noise levels were performed on roads of regional significance of Molėtai

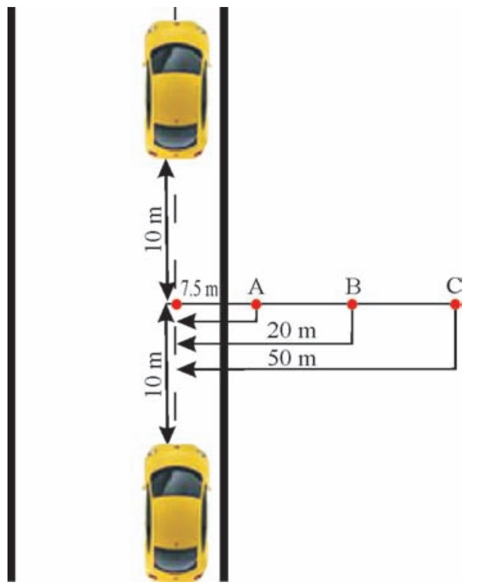


Fig. 1. Points selected to measure noise level produced by a moving vehicle

district. The Molėtai district was chosen due to the fact that it has both asphalt and gravel road pavement.

Typical points in consideration of pavement nature and different environmental conditions were selected (Fig. 2).

The first measurement point was an asphalt road with an arable field on one side and a meadow with thinly growing bushes on the other; an open location was selected for the measurement.

The second measurement point was a gravel road with an arable field on one side and a meadow with thinly growing bushes on the other; an open location was selected for the measurement.

The third measurement point was a gravel road with coniferous wood with thinly growing bushes starting at 10 m from the road on both sides.

The fourth measurement point was an asphalt road with coniferous wood with thinly growing bushes starting at 10 m from the road on both sides.

The fifth measurement point was selected on an asphalt road going uphill with thinly growing bushes and single trees at 15 m from the road on both sides.

The sixth measurement point was selected on a gravel road going uphill with thinly growing bushes and single trees on both sides at 15 m from the road.

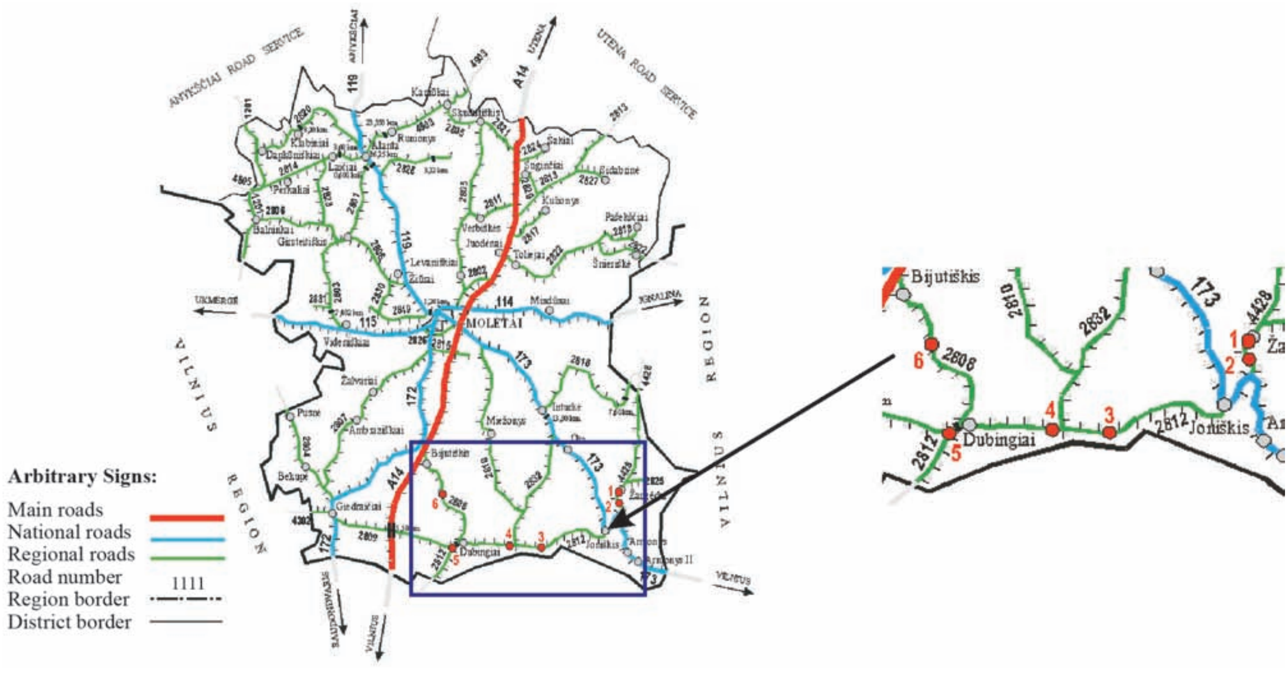
Noise level dependence on light vehicle speed was measured during summertime. The station was located leeward from the road. The wind speed was 1.2 m/s, air temperature 22 °C, relative humidity of 54%. In wintertime measurements were taken also leeward. The wind speed was 1.8 m/s, air temperature 6.3 °C, relative humidity of 44%.

3. Results of transport noise measurement

Fig. 3 shows the reciprocal and max noise levels of a car driving in an open area in wintertime and summertime. Noise levels were measured while a car was driving at a speed of 50 km/h on roads with gravel and AP. As we can see from the figures, upon moving away from the driving car by 7.5 m to 50 m, the reciprocal noise levels on roads with different pavement decreased equally. The difference was 12 dBA in wintertime and 17 dBA in summertime.

As seasons change so do the sound reflections, especially when driving in wooded areas and changes also occur in coarseness of the road pavement. These changes have influence on the fact that reciprocal noise level at a distance of 7.5 m in summertime is higher by 3 dBA than in wintertime. Upon moving away the noise level is higher in wintertime. The max noise level on roads with AP upon moving away from the driving car by 7.5 m to 50 m decreases by 17 dBA in wintertime and 19 dBA in summertime. The max noise level on the road with gravel pavement decreases by 16 dBA in wintertime and 17 dBA in summertime.

On comparing the levels of reciprocal noise on roads with different pavements we see that noise level on roads with gravel pavement, when driving in an open area, is higher by 3 dBA in wintertime and summertime than it is on roads with AP. Noise caused by the tires and car vibrations is a consequence of pavement roughness.



a b

Fig. 2. Noise level measurement points: a – network of roads of national significance of Molėtai district (the rectangle indicates the road sectors researched); b – the configuration of the roads researched (1 to 6 – measurement points)

Fig. 4 shows the reciprocal and max levels of noise of a car driving in wooded area in wintertime and summertime.

This time the reciprocal noise level on roads with AP upon moving away from the driving car by 7.5 m to 50 m decreased by 15 dBA in wintertime and 20 dBA in summertime. The noise level on the road with gravel pavement decreased by 16 dBA in wintertime and 24 dBA in summertime. This is influenced by winter and summer herbaceous vegetation which absorb and reflect noise in different ways.

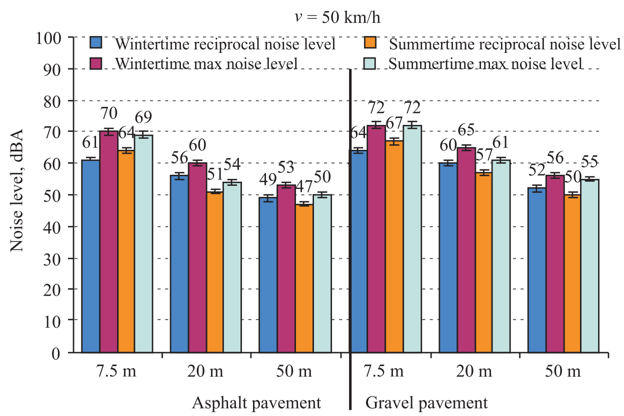


Fig. 3. The reciprocal and the max noise levels of a car driving in an open area

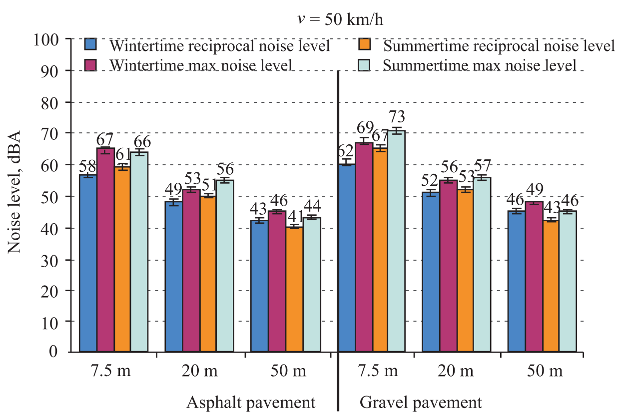


Fig. 4. The reciprocal and the max noise levels of a car driving in the wooded area

The difference was probably influenced by the noise absorption in the wooded area in summertime. The max noise level on roads with AP in the wooded area decreased equally by 22 dBA in summertime and wintertime. The max noise level on roads with gravel pavement decreased by 20 dBA in wintertime and 27 dBA in summertime.

The reciprocal and max noise levels at measurement points of 7.5 m and 20 m in the wooded area were higher in summertime than in wintertime. At the measuring point of 50 m, the noise level was higher in wintertime. The results obtained lead us to an assumption that reflection from foliage of undergrowth and glade form a particular screen which prevents noise from being carried away.

Fig. 5 compares the changes in noise spread in open and wooded areas upon moving away from the noise source by 50 m.

As we can see in Fig. 5 the reciprocal noise level in summertime is lower by 2 dBA than in wintertime. Upon moving away from the noise source by 50 m, motor transport produced reciprocal noise in wooded areas is lower by 6 dBA than in open fields (Fig. 5). The noise spread reduces equally both on roads with AP and gravel roads. All this shows that growing trees have fair influence on noise suppression.

The max noise level in summertime is lower by 1 to 3 dBA than in wintertime (Fig. 5).

Fig. 6 compares noise levels produced by a car driving uphill on roads with asphalt and gravel pavement.

The results obtained show that the reciprocal noise level when driving uphill on the road with gravel pavement at a point of 7.5 m is higher by 4 dBA than on road with AP. This noise at a point of 50 m on road with AP is lower by 3 dBA than on gravel road (Fig. 6).

A light vehicle driving on the road with gravel pavement at a speed of 50 km/h up a hill with a steepness of 5% at a point of 7.5 m produces a noise more intense by 2 dBA than driving on open area at the same speed.

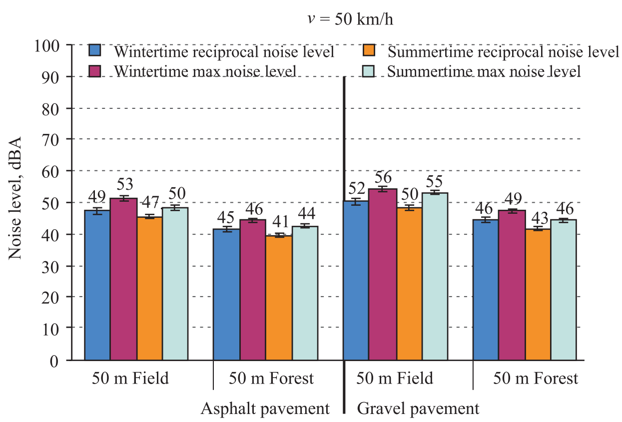


Fig. 5. The reciprocal and the max noise levels spread dependence on landscape conditions

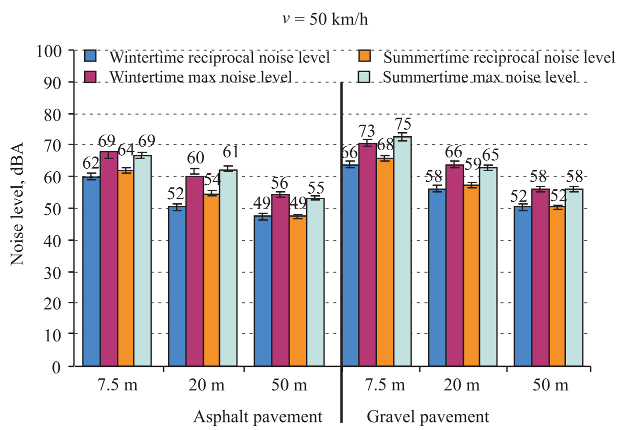


Fig. 6. The reciprocal and the max noise levels of a car driving uphill

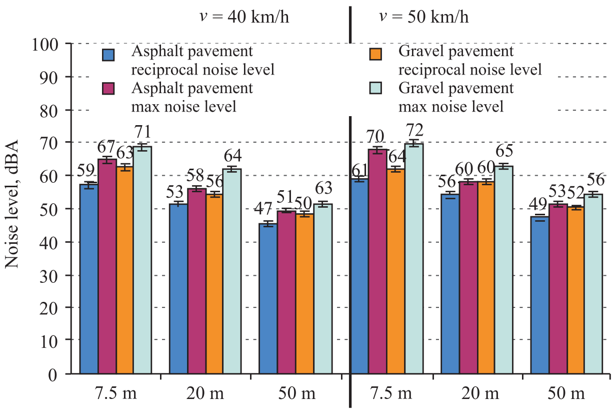


Fig. 7. Dependence of reciprocal and max noise levels on car speed when driving on road with gravel pavement and AP in wintertime

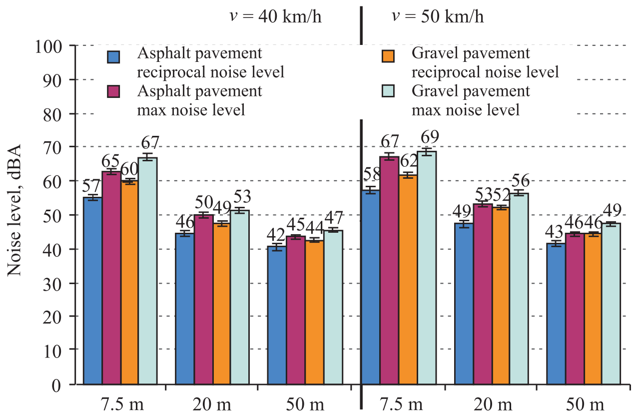


Fig. 8. Dependence of reciprocal and max noise levels on car speed when driving in wooded area on road with asphalt and gravel pavement in wintertime

Fig. 7 shows the dependence of reciprocal and max noise levels on car speed when driving in an open area on roads with asphalt and gravel pavement in wintertime. As light vehicle speed increases from 40 km/h to 50 km/h, the level of reciprocal noise at a distance of 7.5 m from a car rises by 2 dBA. Upon moving away by 7.5 m to 50 m, the spread of the noise produced by a driving car reduces by 12 dBA.

Comparing the noise levels on roads with different pavements we see that reciprocal noise level on roads with gravel pavement is higher by 3 to 4 dBA. This difference in noise levels occurs at all distances (from 7.5 to 50 m) from a driving car.

Fig. 8 shows the dependence of reciprocal and max noise levels on car speed when driving in wooded areas on roads with asphalt and gravel pavement in wintertime. As light vehicle speed increases from 40 km/h to 50 km/h, the level of noise rises by 2 dBA. Upon moving away by 7.5 m to 50 m, the spread of a driving car produced noise on roads with AP decreases by 15 dBA and by 16 dBA on roads with gravel pavement.

A car produced noise on roads with gravel pavement in wooded areas in wintertime is higher by 3 dBA than on roads with AP.

Fig. 9 shows the dependence of reciprocal and max noise levels on car speed when driving in an open area on roads with asphalt and gravel pavement in summertime.

The reciprocal noise level of a car driving at a speed of 50 km/h at a distance of 7.5 m on road with gravel pavement is higher by 3 dBA than on road with AP. When driving at a speed of 70 km/h, the difference is 2 dBA.

The difference of reciprocal noise level of a car driving in an open area at various speeds (from 7.5 to 50 m) can be seen in Fig. 10.

The results obtained show that upon increasing car speed from 50 km/h to 70 km/h, the reciprocal noise level, considering metering points, increases by 5 dBA to 7 dBA on asphalt roads and 4 dBA to 8 dBA on gravel roads.

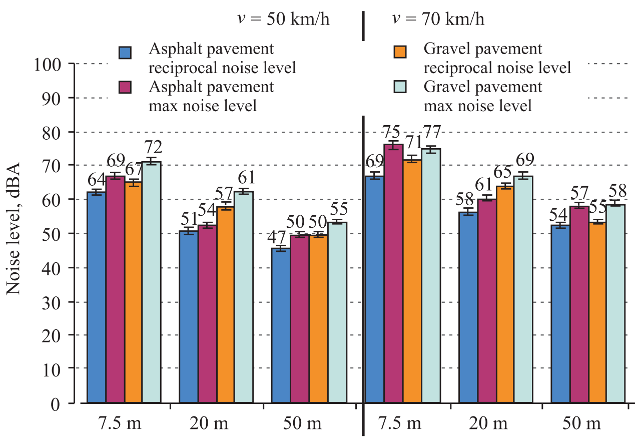


Fig. 9. Dependence of reciprocal and max noise levels on car speed when driving in an open area on road with asphalt and gravel pavement in summertime

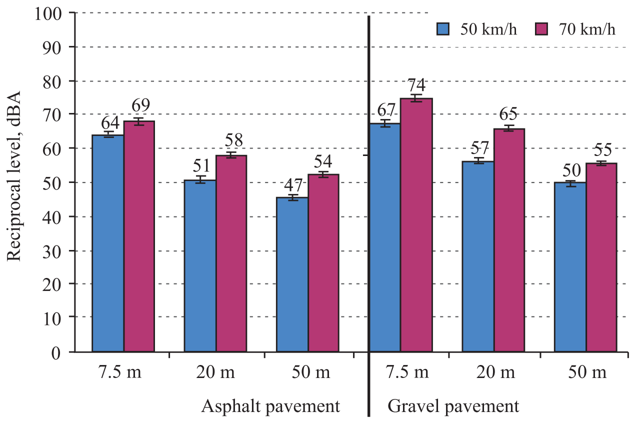


Fig. 10. Dependence of reciprocal noise levels on car speed when driving in an open area on roads with different pavements in summertime

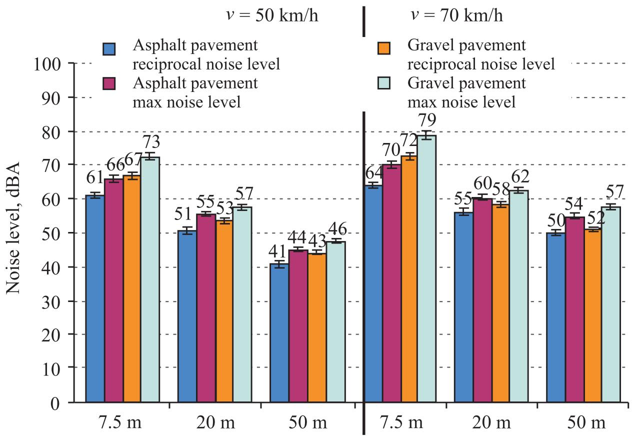


Fig. 11. Dependence of reciprocal and max noise levels on car speed when driving in wooded area on road with asphalt and gravel pavement in summertime

Fig. 11 shows the dependence of reciprocal and max noise levels on car speed when driving in wooded area on roads with asphalt and gravel pavement in summertime.

As we can see, upon increasing speed from 50 km/h to 70 km/h when driving in woods, the noise level on sectors with AP increases by 3 dBA to 4 dBA and 5 dBA to 6 dBA on roads with gravel pavement.

4. Conclusions

Motor transport produced noise depends on the distance from the noise source, car driving speed, territory conformation and obstacles in the way of noise spread (herbs and woody vegetation).

The noise level on roads with gravel pavement when driving in an open area in wintertime and summertime is higher by 3 dBA than on roads with AP.

The noise level in wooded areas on roads with gravel pavement is higher by 4 dBA in summertime and by 6 dBA in wintertime than on roads with AP.

As light vehicle speed increases from 40 km/h to 50 km/h in wintertime the noise level has a tendency to rise by 2 dBA.

As car speed increases from 50 km/h to 70 km/h in summertime the noise level rises by 5 dBA.

Upon moving away from the noise source by 50 m a car produced noise in the open and wooded areas is lower by 2 dBA in summertime than it is in wintertime.

References

Antov, D.; Abel, K.; Sürje, P.; Rõuk, H.; Rõivas, T. 2009. Speed Reduction Effects of Urban Roundabouts, *The Baltic Journal of Road and Bridge Engineering* 4(1): 22–26. doi:10.3846/1822-427X.2009.4.22-26

Bazaras, J.; Jablonskytė, J.; Jotautienė, E. 2008. Interdependence of Noise and Traffic Flow, *Transport* 23(1): 67–72. doi:10.3846/1648-4142.2008.23.67-72

Baltrėnas, P.; Butkus, D.; Nainys, V.; Grubliauskas, R.; Gudaitytė, J. 2007. Efficiency Evaluation of a Noise Barrier, *Journal of Environmental Engineering and Landscape Management* 15(3): 125–134.

Butkus, D.; Januševičius, T.; Grubliauskas, R. 2008. Experimental Test of Internal Wall Construction Elements, in *Proc of the 7th International Conference "Environmental Engineering": selected papers*, vol. 3. Ed. by Čygas, D.; Froehner, K. D. May 22–23, 2008, Vilnius, Lithuania. Vilnius: Technika, 78–84.

Grubliauskas, R.; Butkus, D. 2009. Chamber Research on Acoustic Properties of Materials and Their Evaluation, *Journal of Environmental Engineering and Landscape Management* 17(2): 98–107. doi:10.3846/1648-6897.2009.17.97-105

Grubliauskas, R.; Butkus, D. 2004. Autotransporto triukšmo žiemą magistralėje Kaunas – Zarasai įvertinimas [Evaluation of Motor Transport Noise on the Highway Kaunas – Zarasai in Wintertime], *7-osios jaunųjų mokslininkų konferencijos „Lietuva be mokslo – Lietuva be ateities" straipsnių rinkinys. Transportas* [The 7th Conference of Young Scientists "Lithuania Without The Science – Lithuania Without The Future"]. Vilnius: Technika, 338–346.

Gražulevičienė, R.; Lekavičiūtė, J.; Mozgeris, G.; Merkevičius, S.; Deikus, J. 2004. Traffic Noise Emissions and Myocardial Infarction Risk, *Polish Journal of Environmental Studies* 13(6): 737–741.

Ishizuka, T.; Fujiwara, K. 2004. Performance of Noise Barriers with Various Edge Shapes and Acoustical Cushions, *Applied Acoustics* 65(2): 125–141. doi:10.1016/j.apacoust.2003.08.006

Jonasson, H. G. 2007. A Theory of Traffic Noise Propagation with Applications to L_{eq}, *Journal of Sound and Vibration* 30(3): 289–304. doi:10.1016/S0022-460X(73)80240-8

Kapski, D.; Leonovich, I.; Ratkevičiūtė, K.; Miškinis, D. 2008. Implementation of Experimental Research in Road Traffic: Theory and Practice, *The Baltic Journal of Road and Bridge Engineering* 3(2): 101–108. doi:10.3846/1822-427X.2008.3.101-108

Laurinavičius, A.; Oginskas, R. 2006. Experimental Research on the Development of Rutting in Asphalt Concrete Pavements Reinforced with Geosynthetic Materials, *Journal of Civil Engineering and Management* 12(4): 311–317.

Levine, S.; Hofstetter, P.; Zheng, X. Y.; Henderson, D. 1998. Duration and Peak Level as Co-Factors in Hearing Loss From Exposure to Impact Noise, *Scandinavian Audiol* 48(Suppl.): 27–36.

Malinauskienė, V.; Obelenis, V.; Šopagienė, D. 2004. Triukšmas aplinkoje ir jo įtaka miokardo infarkto rizikai [Environmental Noise and its Influence on Myocardial Infarction Risk], *Sveikatos mokslai* [Health Sciences] 14(3): 41–44.

Miškinis, D.; 2006. Pagrindiniai darbai kelių sektoriuje ir jų finansavimas [The Main Works in Road Sector and Its Financing], *Lietuvos keliai* [Lithuanian Roads] 2: 23–33.

Nemaniūtė, J. 2007. Triukšmo kartografavimas prie pagrindinių kelių [Mapping of Noise Near the Main Roads], *Lietuvos keliai* [Lithuanian Roads] 1: 47–51.

Oškinis, V.; Kinduryte, R.; Butkus, D. 2004. Automobilių triukšmo tyrimų magistraleje Vilnius–Kaunas–Klaipėda rezultatai [The Results of Vehicle Noise Research on the Highway Vilnius–Kaunas–Klaipėda], *Journal of Environmental Engineering and Landscape Management* XII(Suppl 1): 10–18.

Paslawski, J. 2009. Flexibility in Highway Noise Management, *Transport* 24(1): 66–75. doi:10.3846/1648-4142.2009.24.66-75

Passchier, V. W.; Passchier, W. F. 2000. Noise Exposure and Public Health, *Environ Health Perspect* 108(Suppl. 1): 123–131. doi:10.2307/3454637

Radziszewski, P. 2007. Modified Asphalt Mixtures Resistance to Permanent Deformations, *Journal of Civil Engineering and Management* 13(4): 307–315.

Skrodenis, E.; Venckauskaitė, J.; Burinskienė, M. 2009. Substantiation of Communication Infrastructure Selection in Newly Developed Territories, *The Baltic Journal of Road and Bridge Engineering* 4(2): 87–94. doi:10.3846/1822-427X.2009.4.87-94

Toppila, E.; Pyykko, I.; Starck, J.; Kaksonen, R.; Ishizaki, H. 2000. Individual Risk Factors in the Development of Noise – Induced Hearing Loss, *Noise and Health* 2(8): 59–70.

Vaišis, V.; Januševičius, T. 2008. Investigation and Evaluation of Noise Level in the Northern Part of Klaipėda City, *Journal of Environmental Engineering and Landscape Management* 16(2): 89–96. doi:10.3846/1648-6897.2008.16.89-96

Vaiškūnaitė, R.; Laurinavičius, A.; Miškinis, D. 2009. Analysis and Evaluation of the Effect of Studded Tyres on Road Pavement and Environment (II), *The Baltic Journal of Road and Bridge Engineering* 4(4): 203–211. doi:10.3846/1822-427X.2009.4.203-211

Zavadskas, E. K.; Kaklauskas, A.; Kaklauskienė, J. 2007a. Modelling and Forecasting of a Rational and Sustainable Development of Vilnius: Emphasis on Pollution, *International Journal of Environment and Pollution* 30(3–4): 485–500. doi:10.1504/IJEP.2007.014824

Zavadskas, E. K.; Kaklauskas, A.; Peldschus, F.; Turskis, Z. 2007b. Multi-attribute Assessment of Road Design Solution by Using the COPRAS Method, *The Baltic Journal of Road and Bridge Engineering* 2(4): 195–203.

Willich, S. N.; Wegscheider, K.; Stallmann, M.; Keil, T. 2006. Noise Burden and the Risk of Myocardial Infarction, *European Heart Journal* 27(3): 276–282. doi:10.1093/eurheartj/ehi658

Обелянис, В.; Малинаускене, В. 2004. Исследование профессиональных факторов и здоровья работников городского автотранспорта [Obelianis, Malinauskienė. Investigation of Occupational Factors and Health of Urban Transport Workers], *Медико-социальная экспертиза и реабилитация: сборник научных статей* [Medical and Social Expertise and Rehabilitation: Collection of Scientific Articles] 6: 327–330.

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