JOURNAL OF ENVIRONMENTAL ENGINEERING
AND LANDSCAPE MANAGEMENT
2009
17(3): 181–188

MODELLING OF NOISE LEVEL IN THE NORTHERN PART OF KLAIPĖDA CITY

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Submitted 19 Jun. 2007; accepted 29 May 2009

Abstract. Noise is an urgent problem not only in Lithuania but also all over the world. There are no noise-reducing walls in the northern part of Klaipėda that could be used as reducers of noise spread from streets to the residential territory. Equivalent noise level spread from streets to the residential territory during the day and night time is modelled in this work. Comparison of measured and modelled noise level is carried out. A wall made from plastics, wood and ferro-concrete was used as a noise reducer in a model for reducing noise level spread to the residential territory. A wall of 2 and 3 m height was also used for wall efficiency study. Noise level dependence on car velocity is determined in I. Kantas street which is cobbled with stones. Modelling of noise level dependence on car velocity in I. Kantas street is also carried out and modelling results are compared with experimental results.

Keywords: noise level, noise-reducing wall efficiency, residential territory.

1. Introduction

Car transport, being a specific pollution source, is dynamic; it penetrates all the territories of a town, including living and industrial districts, centres, hospital and sanatorium areas as well as recreational areas (Oškinis *et al.* 2004; Van Maarseveen and Zuidgesst 2003).

About 15–30% of residents of various countries encounter noise with a level exceeding 65 dB. Along with growing intensity in the life rhythm, the noise problem becomes more and more urgent (Vasarevičius and Graudinytė 2004). Integration into the common European market, growing economy, raising level of salaries lead to increased need of transportation in the Central and East European countries. Therefore, one of the most important tasks is to find a favourable solution for reduction of adverse environmental impact (Gražulevičiūtė and Deikus 1998).

Along with a growing number of cars, noise level is growing in Lithuania as well. The principle of EU policy for noise limitation is to reduce noise emission of the industrial products entering the market, including overground vehicles, plains as well as field equipment (Bottazzi 2003).

All the European Union countries apply increasingly more stringent requirements for transport (Žeromskas 2000; Lebovics 2000).

European Transport, Environment and Health Charter (1999) notes that the noise of traffic causes communication and learning problems, sleep disturbances. Recent scientific research shows that noise is the health risk when its level is higher than 65 dBA during the day and 55 dBA night time (Triukšmo ... 2002).

The growing volume of traffic forces to look for opportunities of how to reduce noise. In particular this is urgent for residents living near railways and roads. For ambient noise reduction, different measures are applied. Sound waves detour from the source declining, so a buffer zone and shields would protect people from noise (Batrėnas *et al*. 2007).

Recently, the European Union system requires that noise of vehicles and related problems are tackled efficiently and rationally. The target is to reduce noise to minimum (Grubliauskas *et al*. 2006).

Unlike the recent reduction of industrial noise, street traffic noise, the increase in transport volume, is intensifying. Long-term sound strength depends on the size of emission, vehicle condition, speed, road pavement, buildings. Doubling of the transport volume increases noise by 3 dB (A), doubling of the speed increases noise by 12 dB (A). The engine emits most noise mainly switched on the first gear, rolling sound starts from 50 km/h speed, and driving trucks constantly spread the engine rumble (Žeromskas 2000).

Noise pollution from industrial facilities spreads in various technological processes of loading and unloading goods from trucks or cars.

At the first three points of measuring in the northern part of Klaipėda city the noise level is predetermined by the nearby stevedoring JSC KLASCO; it is caused by car loading and unloading operations.

The objectives of the study are to model the noise level and spread in the northern part of Klaipėda city and to compare the results with data from the field study.

2. Study methods

The noise level in Klaipėda is modelled using the noise modelling program CadnaA.

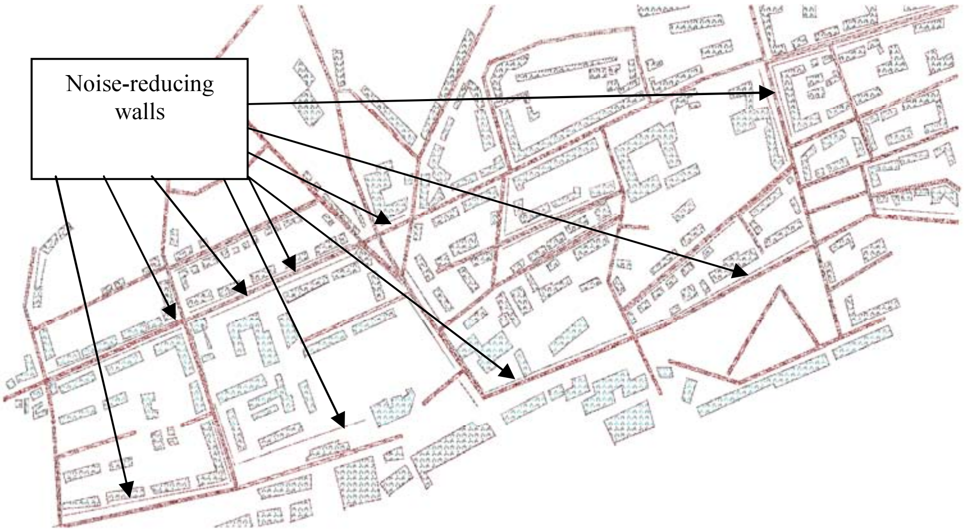

Fig. 1. Modelling scheme of northern part of Klaipėda city with noise-reducing walls

One of the advantages of this software is that noise emissions are calculated on the basis of the European Union-approved methodologies (for road transport: NMPB-Routes-96), so modelling results can be compared with the Lithuanian and EU norms and requirements of the noise level. The software has many other advantages, especially in comparison with other programmable noise forecasting equipment used in Lithuania (Batrėnas *et al.* 2004).

During modelling of the spread of noise with the noise-modelling program CadnaA, the city map with streets and buildings, which corresponds to the city plan and urban scale, is loaded into the program. Number of storeys is entered into the program for each building individually. The plan outlines the noise-reducing walls, where they are planned to be built. Urban noise simulation is shown on the map (Fig. 1).

The program calculates the noise level in view of the car traffic and speed, so each street is entered with traffic flow per day and car speed. Each street area, pavement type – asphalt concrete, concrete, gravel, etc. – are introduced into the model individually (Beranek and Ver 1992).

Height and material are introduced for each noise-reducing wall. In this model, 2 and 3 m high noise-reducing walls made of corrugated plastic with a thickness of 10 mm, 40 mm and coniferous boards of 40 mm and reinforced concrete of 50 mm are used. The program models noise spread during the day and night time.

3. Noise level modelling

Fig. 2 shows the equivalent noise level in the northern part of Klaipėda during the day time. Noise level depends directly on the car speed and intensity of traffic flow (Vaišis, Januševičius 2006).

At the first three measuring points, the equivalent noise level, according to modelling results obtained, is about 50 dBA, and the measurement of the average equivalent noise level is 53 dBA. At measuring point 4 modelling results gave the equivalent noise level of 54 dBA, and according to the measurements it was 56 dBA. The highest noise level is measured in the sites near Naujasis Uostas street, where the equivalent noise level of simulation data reached 68 dBA and exceeded the permissible equivalent noise level (PNL) by 3 dBA, and according to measuring data, the average equivalent noise level was 70 dBA, exceeding PNL by 5 dBA.

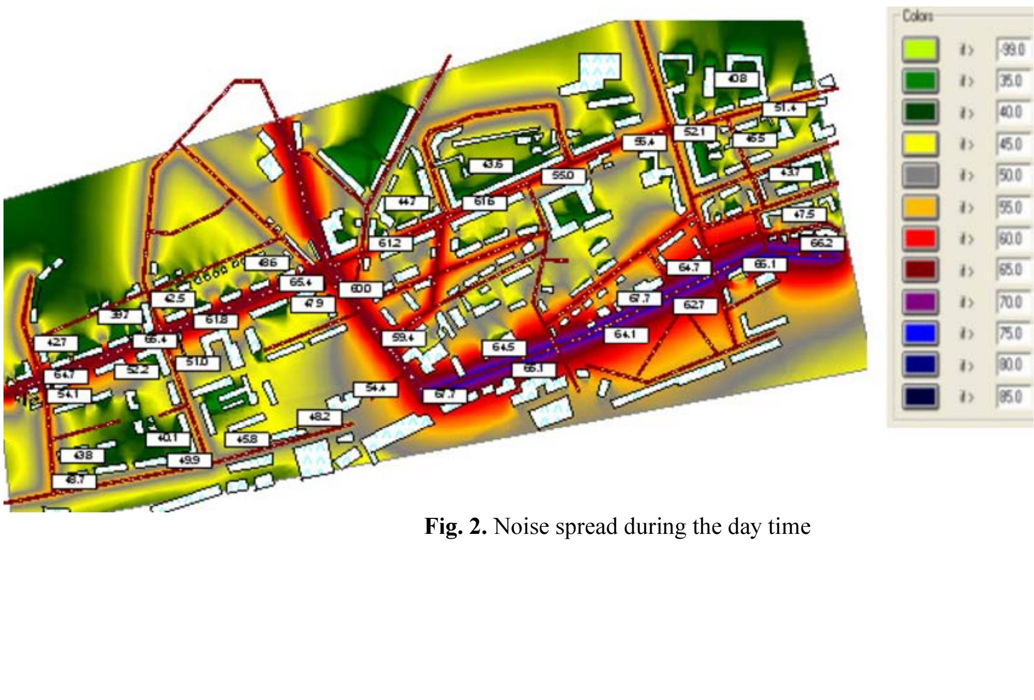

Fig. 2. Noise spread during the day time

The lowest equivalent noise level in the modelling data was obtained at measuring point 8. At this point the noise level of simulation data reached 48 dBA, and when measuring average equivalent noise level was 55 dBA. This measuring site is located away from busy traffic flows and intensive use of streets. The noise level in the measuring site is determined by bypassing individual cars and parked car alarms, and the modelling program calculates the noise level according to car traffic, street pavement type and terrain, so the modelling and measurement data differ. At measuring point 9 the modelled equivalent noise level reached 52 dBA, measurement resulted in 57 dBA. At measuring point 10 the modelled equivalent noise level was 53 dBA, and the measured average equivalent noise level was 57 dBA. At measuring point 11 the modelled equivalent noise level was 48 dBA, and the measured equivalent noise level was 54 dBA. In I. Kantas street with measuring points 12 and 13 the modelled equivalent noise level was 62 dBA, and the measured average equivalent noise level was 60 dBA. At measuring point 14 the modelled equivalent noise level was 65 dBA, and the measured average equivalent noise level was 61 dBA. At measuring point 15 the modelled equivalent noise level was 62 dBA, and the measured average equivalent noise level was 58 dBA. At measuring points 16 and 17 the modelled equivalent noise level was 65 dBA, and the measured average equivalent noise level was 63 dBA.

The highest noise level was measured in streets with maximum flow of cars and exploitation. The highest noise spread was estimated from Naujasis Uostas street. This street is passed by most of cars, and the noise level is up to 70 dBA and exceeds PNL by 5 dBA. A high noise level was measured in Sportininkai street. A lower noise level was measured in Švyturys, Šimkus and Puodžiai streets. I. Kantas street is an exclusive street, it has buildings built on its both sides and is paved with stones.

The maximum noise level dominates on streets and near the facades of houses oriented towards the street. A lower noise level is measured in residential courtyards, where the noise spread from the street is reduced by houses the facades of which serve as a noise-isolating barrier.

During the day, traffic is intense and noise level in many places of measurement exceeds the maximum equivalent noise level. At a rather high noise level a large proportion of the population, with windows oriented to the street, are exposed to increased noise levels which have a negative impact on their health.

During the night allowable equivalent noise level is 55 dBA. In the first two measuring locations the modelled noise level was 41 dBA, while the average measurements of the equivalent noise level was 48 dBA. Modelling of measuring point 4 gave 46 dBA noise level, and the measurement resulted 50 dBA equivalent noise level. Measuring points 5 to 7 represented the equivalent noise level of 61 dBA and exceeded PNL by 6 dBA; when measured it was 56 dBA and exceeded PNL by 1 dBA. In Puodžiai street, where measuring point 8 is located, the modelled noise level was 44 dBA; when measured it was 42 dBA.

In the second measurement area located at measuring point 9 modelling results gave the noise level of 44 dBA, when measured it was 48 dBA. At measuring point 10 the modelled noise level was 45 dBA, and when measured it was 49 dBA. At measuring point 11 modelling results gave the equivalent noise level of 46 dBA, and according to the measurement, it was 13 dBA. In I. Kantas street, in which measuring points 12 and 13 are situated the modelled equivalent noise level was 51 dBA, and when measured it was 48 dBA. The equivalent noise level, according to the modelling data, reached 52 dBA at measuring point 14. At measuring point 15 modelling results gave the equivalent noise level of 50 dBA during the night time, and according to measurements, it was 53 dBA. At measuring points 16 and 17 modelling results gave the equivalent noise level of 55 dBA during the night time, and according to measurements it was 52 dBA.

During the night time a high noise level like that during the day time was in Naujasis Uostas street (Fig. 3). In the other streets, after reduction, noise level also decreased significantly even in traffic time. During the night time a low noise level was behind houses and in courtyards, directly protected from the street noise by buildings. But, with windows oriented to the street side, residents are exposed to increased noise levels, which at night have a greater negative impact than during the day.

4. The level of noise spread to the residential territory after application of noise-reducing walls

In order to reduce the noise level of urban areas noise-reducing walls can be built, which occupy little space and ensure a high noise reduction factor. However, in very densely built-up areas, noise-reducing walls are not possible everywhere. In order to analyse a noise-reducing wall performance model, in places where it is possible to install such walls, noise-reducing walls of 2 and 3 m in height are entered. The level of noise reduction is studied by using noise-reducing walls made of corrugated plastic, wooden planks and reinforced concrete. By means of a 2 m high noise-reducing wall, made of corrugated plastic (Fig. 4), the maximum noise level is reduced by up to 5 dBA in Naujasis Uostas street.

In order to investigate dependence of noise-reducing wall efficiency on height, since the noise wave hitting the wall looses a part of its energy by penetrating through it, and a part of the wave breaks above the noise-reducing wall and continues to spread to the residential area, we heightened the wall of corrugated plastic from 2 to 3 m. By heightening the noise-reducing wall by 1 m, noise level is reduced by additional 1 dBA (Fig. 5).

During the night time by use of a noise-reducing wall of corrugated plastic the noise level in Naujasis Uostas street is reduced by 5 dBA, but the permissible noise level is still exceeded by up to 2 dBA. In Šimkus street the noise level is reduced by 4 dBA, in Sportininkai street the noise level fell by 4 dBA (Fig. 6) and PNL is no longer exceeded.

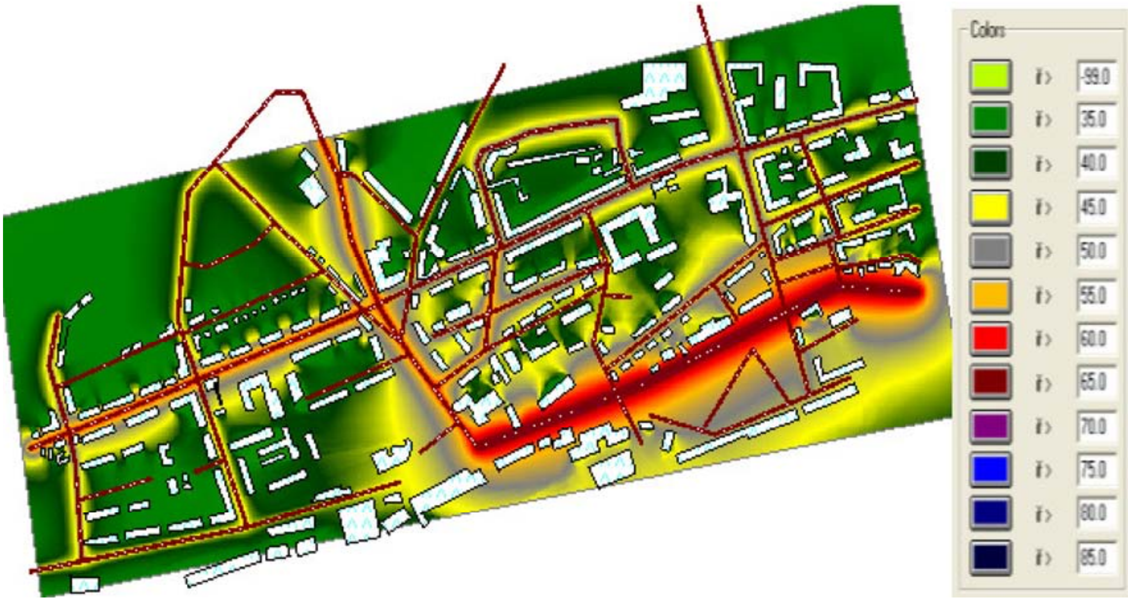

Fig. 3. Noise spread during the night time

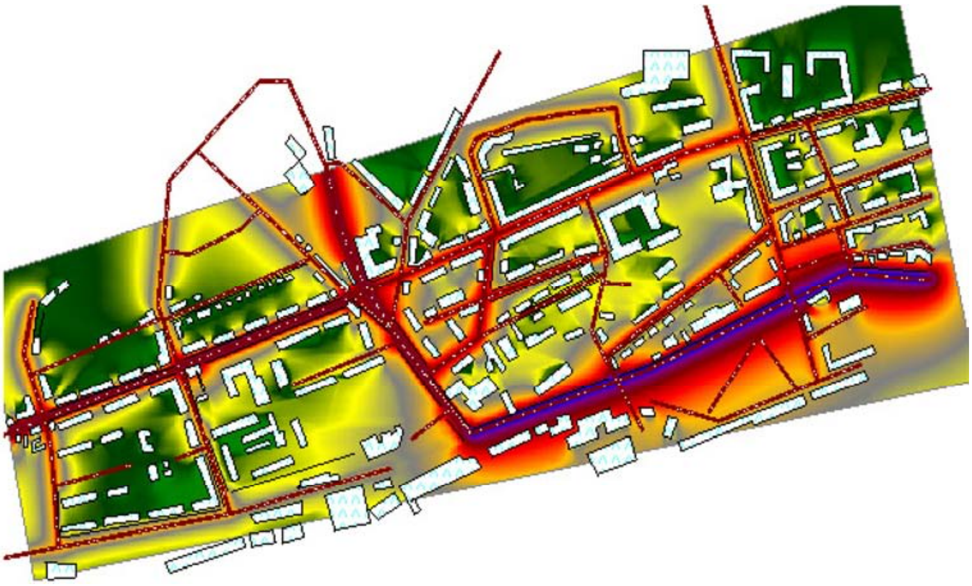

Fig. 4. Noise spread at 2 m high noise-reducing wall during the day time

Fig. 5. Noise spread at 3 m high plastic noise-reducing wall during the day time

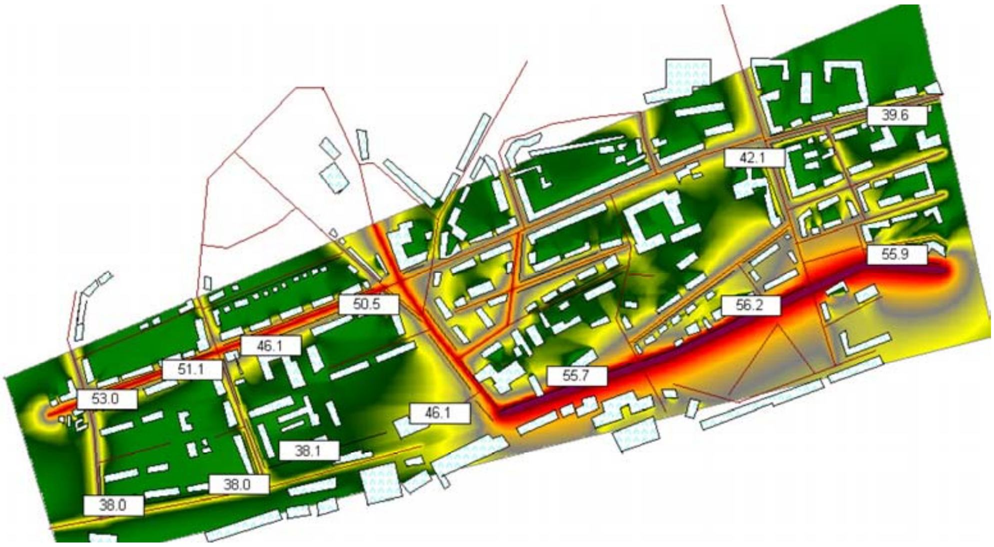

Fig. 6. Noise spread at 3 m high plastic noise-reducing wall during the night time

Fig. 7. Noise spread at 3 m high wooden noise-reducing wall during the day time

Fig. 8. Noise spread at 3 m high wooden noise-reducing wall during the night time

Fig. 7 shows the level of noise reduction by use of a wooden noise-reducing wall, 3 m high. During the day time, the noise level is reduced by 8 dBA in Naujasis Uostas street, by 7 dBA in Šimkus street, by about 8 dBA in Sportininkai street, and by about 4 dBA in Švyturys street. Use of a wooden wall leads to a permissible noise level in Naujasis Uostas street.

Fig. 8 shows the level of noise at night, using a wooden noise-reducing wall, 3 m high. Noise level is reduced by 8 dBA in Naujasis Uostas and Šimkus streets. Equivalent noise level is reduced by 9 dBA in Sportininkai street.

Fig. 9. Noise spread at 3 m high concrete noise-reducing wall during the day time

Fig. 10. Noise spread at 3 m high concrete noise-reducing wall during the night time

In Švyturys street the equivalent noise level is reduced by 8 dBA. Use of a noise-reducing wall, 3 m high, leads to the permissible noise level.

Fig. 9 shows the level of noise during the day time, having used a noise-reducing reinforced concrete wall of 3 m. By using a reinforced concrete wall the noise level was reduced up to 10 dBA in Naujasis Uostas street. In Šimkus street the equivalent noise level drops by up to 7 dBA. In Sportininkai street the equivalent noise level was reduced by up to 8 dBA. In Švyturys street the equivalent noise level was reduced by up to 5 dBA.

Fig. 10 shows the equivalent noise level reduction during the night time using a reinforced concrete noise-reducing wall of 3 m height. In Naujasis Uostas street the noise level drops by up 10 dBA, in Šimkus street the equivalent noise level is reduced by up to 7 dBA.

Use of a reinforced concrete noise-reducing wall leads to PNL both during the day and night time.

5. Modelling of noise level dependence on car speed

In I. Kantas street, which is paved with stones and built up on both sides with dwelling houses, the noise level dependence on the car speed was tested. A passenger car was driving at a known steady rate. Measurements were made for car speed of 30 km/h, 40 km/h and 50 km/h. Measurements were repeated three times, the average values of measurements are given in Fig. 11.

Figs. 12 and 13 show modelled noise level, depending on car speed.

According to the modelling data, the noise level in I. Kantas street, when the car speed is lowered from 50 km/h to 30 km/h, is reduced by 5 dBA. High change in the noise level, having reduced traffic speed, is due to cobbled streets.

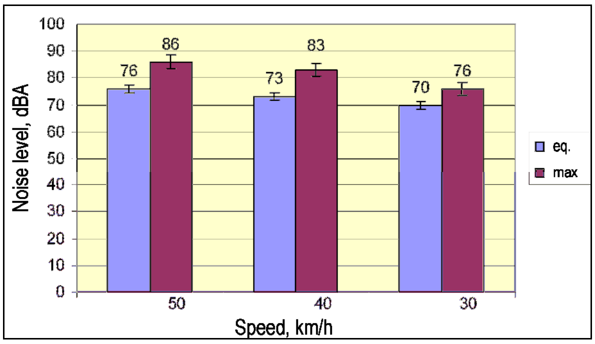

Fig. 11. Equivalent and maximum noise level dependence on car speed

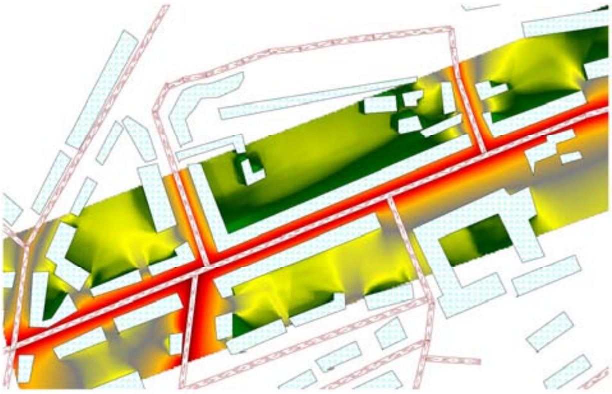

Fig. 12. Noise level in I. Kantas street for car speed of 50 km/h.

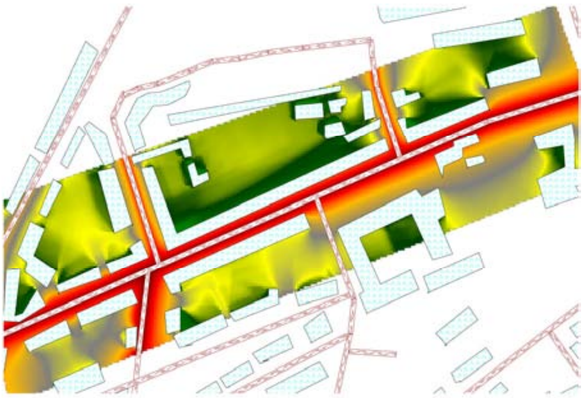

Fig. 13. Noise level in I. Kantas street for car speed of 30 km/h.

Comparison between the modelled noise level results and the results obtained in experimental studies gives about 10% of error.

6. Conclusions

1. Modelling of the noise level dependence on car speed in I. Kantas street, after changing the car speed from 50 km/h to 30 km/h, the noise level dropped by 5 dBA.

2. Modelling and experimental investigation results differ by up to 10%. The lowest noise level was obtained at measuring points 1, 2, 3, 8 and 11 which are in the streets with less traffic.

3. The highest level of noise is in Naujasis Uostas street, which has the busiest traffic flow and the permissible equivalent noise level (PNL) is exceeded by 5 dBA.

4. During the night time PNL was slightly exceeded in Naujasis Uostas street; it exceeded PNL by up to 3 dBA. The minimum noise level was obtained in Sportininkai, Puodžiai and Kantas streets.

5. After modelling the noise spread into the residential area using 2 and 3 m high noise-reducing walls, more efficient noise level reduction was obtained at the higher wall.

6. Using a corrugated plastic noise-reducing wall of 3 m, the equivalent noise level was reduced by up to 6 dBA.

7. Using a wooden wall for noise reduction, the equivalent noise level was reduced by up to 8 dBA.

8. Using a reinforced concrete wall for noise reduction, the equivalent noise level droped by up to 10 dBA, but the reinforced concrete wall reflected noise instead of absorbing it.

9. It is most useful to construct wooden noise-reducing walls.

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TRIUKŠMO LYGIO ŠIAURINĖJE KLAIPĖDOS DALYJE MODELIAVIMAS

V. Vaišis, T. Januševičius

S a n t r a u k a

Triukšmas – ne tik Lietuvoje, bet ir visame pasaulyje aktuali problema. Šiaurinėje Klaipėdos dalyje nėra triukšmą mažinančių sienelių, kurios slopintų triukšmo sklidimą nuo gatvių į gyvenamąją teritoriją. Sumodeliuotas ekvivalentinis triukšmo, sklindančio nuo gatvių į gyvenamąją teritoriją dieną ir naktį, lygis. Išmatuotasis ir sumodeliuotas triukšmo lygiai palyginami. Sumodeliuotas triukšmo lygio gyvenamojoje teritorijoje sumažėjimas esant plastikinei, medinei ir gelžbetoninei sienelei nuo triukšmo. Atlikta 2 ir 3 m aukščio sienelių efektyvumo tyrimas bei triukšmo lygio priklausomumo nuo automobilių greičio akmenimis grįstoje I. Kanto gatvėje analizė. Palyginti triukšmo lygio dėl automobilių greičio I. Kanto gatvėje modeliavimo ir matavimo rezultatai.

Reikšminiai žodžiai: triukšmo lygis, triukšmą mažinančių sienelių efektyvumas, gyvenamoji teritorija.

МОДЕЛИРОВАНИЕ ШУМОВОГО УРОВНЯ В СЕВЕРНОЙ ЧАСТИ ГОРОДА КЛАЙПЕДЫ

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Р е з ю м е

Проблема шума является актуальной не только в Литве, но и во всем мире. В северной части города Клайпеды нет заградительных стенок, которые уменьшали бы распространение уличного шума в жилые зоны. Построена модель распространения уровня эквивалентного шума с улиц в жилые зоны днем и ночью, проведен сравнительный анализ измеренного и смоделированного шума. Построена модель уменьшения уровня шума при наличии стенок из пластика, дерева, железобетона. Проведены исследования эффективности стенок по уменьшению распространения шума при их высоте в 2 и 3 м. Проведены исследования зависимости уровня шума от скорости движения автомобилей по булыжной мостовой ул. И. Канта, построена модель. Проведен сравнительный анализ уровня измеренного и смоделированного шума для ул. И. Канта.

Ключевые слова: уровень шума, эффективность стенок по уменьшению распространения шума, жилая зона.

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