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INVESTIGATION AND EVALUATION OF SPEED TABLE INFLUENCE ON TRAFFIC NOISE PROPAGATION IN RESIDENTIAL AREA

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Abstract. Speed table is an artificial road (street) surface irregularity, which is used to reduce speed of road traffic or maintain allowed speed limit in road (street) section. These measures are used to reduce risk for pedestrians by reducing speed of passing vehicles. Before speed table, vehicles usually reduce speed, after passing it, vehicles usually increase their speed and this could increase traffic noise. Measurements were carried out during the day time in L. Asanavičiūtės Street 5, Vilnius. Measurements were divided into two parts, inside the residential apartment building and in its environment. Near the speed table recorded sound level was 69 dB, inside the residential apartment building noise level was approximately 41 dB. In this paper speed table influence on traffic noise propagation in residential area is investigated.

Keywords: traffic noise, speed table, residential area.

Introduction

To reduce accidents in roads traffic calming measures were developed. Traffic calming is the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behaviour and improve conditions for non-motorized street users (Lockwood 1997). It is indicated that traffic calming could mean anything from lowering speeds to an all-encompassing transportation policy. To decrease the speed of vehicles in urban conditions, various types of road bumps can be used. These measures require the vehicle to slow before the bump and usually its speed increases after the bump, adding an accelerating engine to the noise sources (Elioy, Vogiatzis 2012).

A speed table is a raised flat-topped device, which is placed across the roadway. Speed tables are usually 76 to 101 millimetres in height. The flat-top is approximately 3 metres in the direction of travel and each ramp is 1,8 metres. The flat-top is usually constructed of asphalt, concrete, brick, or other textured materials. The ramps are parabolic in shape and are usually made of asphalt. Speed tables extend fully across the roadway but are tapered on each side to allow unimpeded water flow in curb and gutter system. The design speed for a speed table is approximately 30 kph, which is a safe and comfortable speed for passenger vehicles (Seidel 2007)

Vehicle approaching traffic calming measure decelerates and after crossing it accelerates. A speed bump reduces traffic noise levels during the deceleration phase and increases them during the acceleration phase (Kokowski, Makarewicz 2005). A road bump affects noise emission from a moving vehicle as a result of the enforced deceleration and acceleration.

In Kokowski and Makarewicz research it was shown that between deceleration and acceleration phase sound level difference is equal approximately to 10 dB (Kokowski, Makarewicz 2005)

The traffic noise depends on the intensity of traffic flow. According to Gražulevičienė and Bendokienė study in Kaunas city, Lithuania, highest noise levels were at the street where the traffic flow is most intense (Gražulevičienė, Bendokienė 2009; Paožalytė *et al.* 2012).

Noise exposure causes a number of predictable short-term physiological responses mediated through the autonomic nervous system. Exposure to noise causes physiological activation including increase in heart rate and blood pressure, peripheral vasoconstriction, and thus increases peripheral vascular resistance (Stansfeld, Matheson 2013; Rabinowitz 2005; Butkus *et al.* 2015).

It has been postulated that noise exposure creates annoyance which then leads on to more serious psychological effects. This pathway remains unconfirmed; rather it seems that noise causes annoyance and, independently, mental ill-health also increases annoyance (Stansfeld, Matheson 2013)

According to a recent study by the World Health Organization Regional Office for Europe (WHO 2011), 20 % of the population of EU countries is exposed to traffic noise levels of above 65 dB during the day and 30% is exposed to levels of over 55 dB at night, which translates as a loss of 61,000 disability-adjusted life years. For levels above these values, which are considered health-protective, many studies report statistically significant associations between exposure to noise and sleep disturbance, cardiovascular disease, endocrine responses and psychiatric disorder. Exposure to continuous noise of 85–90 dB, particularly over a lifetime in industrial settings, can lead to a progressive loss of hearing, with an increase in the threshold of hearing sensitivity.

In this paper the traffic noise emissions in the residential area and, more precisely, the noise which is made by the vehicles passing through speed tables is investigated

Methodology

The aim of noise measurement is to identify noise levels in measurement points, and define minimum $L_{AFmin,}$ equivalent L_{AeqT} and maximum L_{AFmax} sound levels.

Sound level measurements was taken by precise first class handheld sound level analyser "Bruel & Kjaer 2270" (Fig. 1). Danish manufactured equipment is one of the most modern first class sound level meters and analysers. This handheld analyser is capable of all required sound level analysis. This analyser meets requirements of sound level meters standard IEC 61672, and other older standards as IEC 60651, IEC 60804 and newest ANSI standards. "Bruel & Kjaer 2270" is capable of measuring sound at frequencies from 1 Hz to 20 kHz. With this tool the effective sound level, defined as A or C characteristics or in different frequency bands, which are identified by standardized filters, can be measured. In direct measurement "Bruel & Kjaer 2270" hand held sound analyser gives uncertainty of 1.5%.

Fig. 1. Handheld sound analyser "Bruel & Kjaer 2270" with mounted windscreen

Noise measurements were taken according LST ISO 1996-1:2003 and standard ISO 1996-2:2007. Sound levels in building was evaluated according HN 33:2011 thresholds and recommendations will be given.

When measurements are being taken outside a windscreen is required. Sound level analyser "Bruel & Kjaer 2270" automatically detects when the windscreen is being mounted or removed, and applies the corresponding correction filter. The specific windscreen information is saved permanently with the measurement setup and data. Equipment is being calibrated before and after measurements according to the manufacturers' manual.

Noise measurements were taken outside near the speed table (1 meter from speed table), near the chosen building to analyse (2 meters away from closest wall to the speed table). Microphone handling height in all measurement points was 1.5 meter from pavement. Noise measurements in residential building were taken in first, third and fifth floors to cover noise propagation in whole building, microphone handling height was also 1.5 meter from floor. During every measurement passing cars were counted and divided into light and heavy transport.

Noise measurements were taken in L. Asanavičiūtės Street. The speed table is 9.0 m length, 0.1 m height, width is the same as of road – 11.0 m. Chosen building is the 5 storey residential apartment building. Two measurement points were chosen in the environment of apartment building (1 meter from speed table and 8 meters distance from speed table, 2 meters near the chosen building), three measurement points were chosen inside the chosen building in first, third and fifth floor of building. And two other reference points were chosen were speed table doesn't do impact on traffic noise. In Figure 2 scheme of measuring points in the apartment building environment and inside the building is shown.

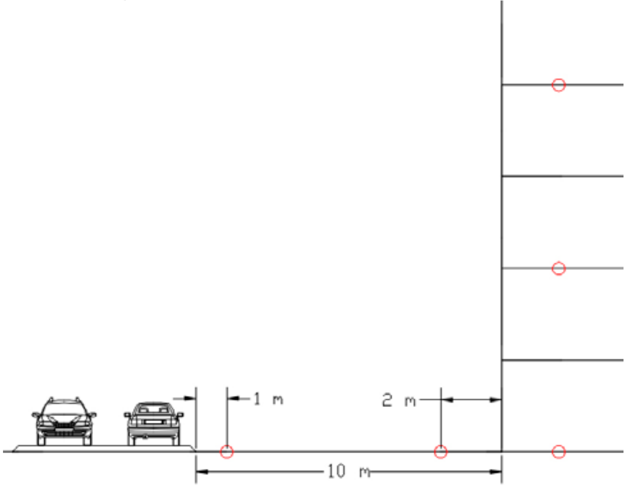

Fig. 2. Scheme of measurement points near speed table and inside residential apartment building

First measurement point was chosen near the 1 m near the speed table. Another point was chosen 2 m near the closest wall of apartment building. Chosen building for study is five floors residential apartment building, measurement was taken in first, third and fifth floors staircases according to the standard ISO 1996-1:2003. Other two reference points were chosen on the same street in the distance of 100 m from speed table. Reference points are shown on the map in Figure 3.

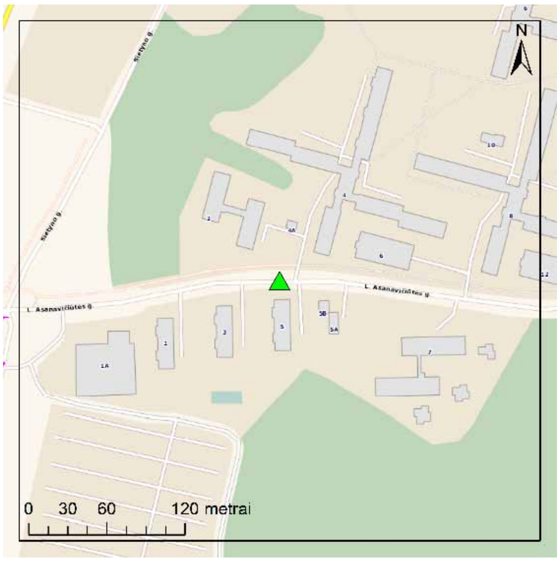

Fig. 3. Plan of measurement site. Green triangle is aplace of speed table, black dots reference measuring points

Results

During the measurements different cars were measured. While measuring first floor of apartment building 39 light vehicles passed the speed table, third floor – 63 light vehicles and 3 heavy vehicles, fifth floor – 60 light vehicles passed by.

The chart of traffic noise (Fig. 4) inside the residential apartment building shows that the infrasound frequencies are higher at the first floor (from 6.3 to 16 Hz). In other frequencies higher traffic noise level is in the upper floors (3rd and 5th). The measurements shown that the biggest noise at the most frequencies was identified in the third floor of apartments building.

In Figure 5 measurement noise levels comparison with Lithuanian hygiene norm HN 33:2011 is shown. Measurement were taken during the day. During the day threshold level of equivalent sound level is 45 dB and for maximum sound level is 55 dB. In the first and fifth floor the equivalent sound levels is lower than the threshold sound level 38 dB and 41 dB respectively, but in third floor sound level is the same as threshold sound level 45 dB.

Maximum sound levels reach threshold level in all measured floors. In the first floor maximum sound level was 55 dB, same as threshold level. But in the third and fifth floor sound level was higher than threshold level by 8 and 2 dB respectively.

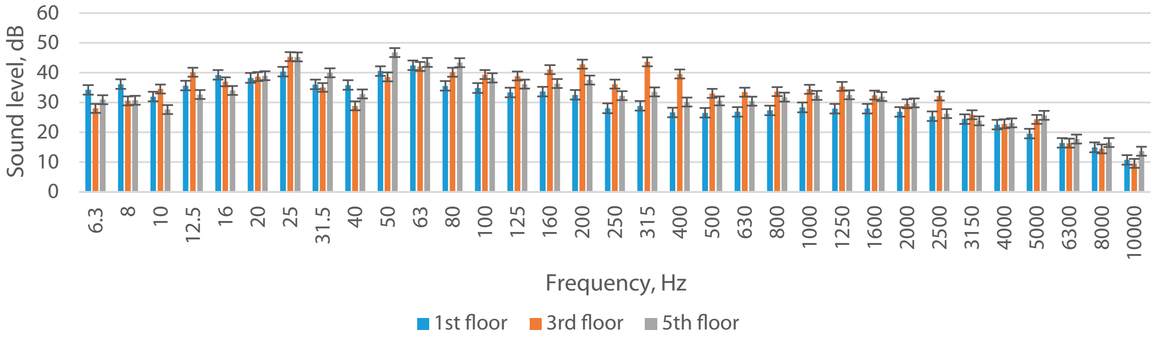

Fig. 4. Noise levels in different frequency bands. Measurement points inside the apartment building

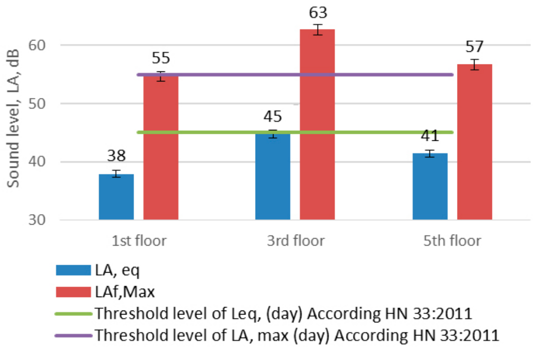

Fig. 5. Noise levels comparison inside the residential apartment with Lithuanian hygiene norm HN 33:2011 threshold levels

During measurements outside the apartment building at measurement point 1 m away from speed table passed by 42 light vehicles, near the apartment building – 42 light vehicles, reference point 1 m away from street – 66 light vehicles, reference point 10 m away from street – 42 light vehicles.

The noise measurements outside, in the residential apartment building environment (Fig. 6) shown that the highest noise levels at low (6.3 – 200 Hz) frequency were at measurement point in 1 meter distance from the speed table. In comparison with the reference point 1 m away from the speed table induced higher noise at low (6.3 – 200 Hz) and middle (250 Hz – 6300 Hz) frequencies, at high frequencies

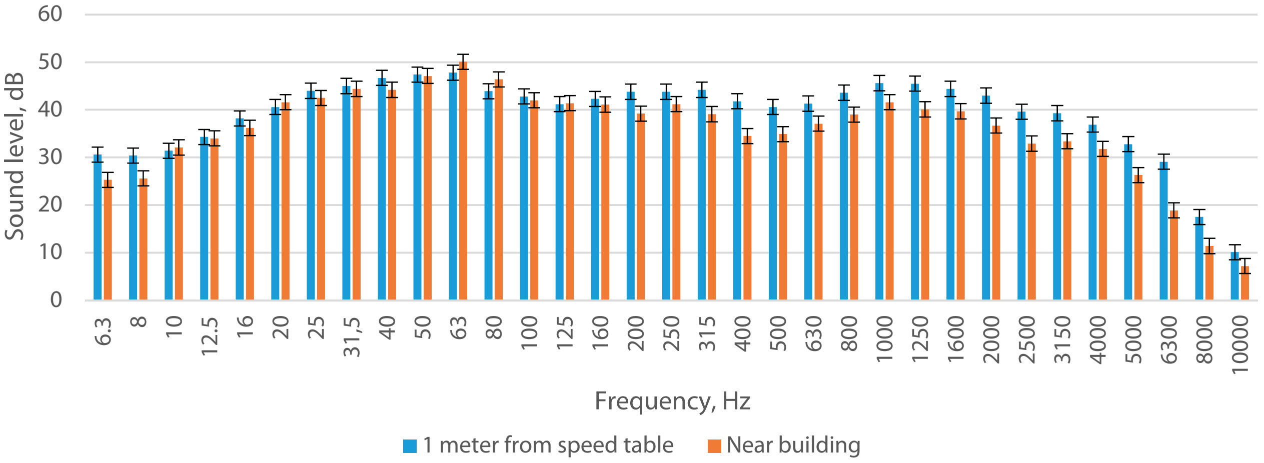

Fig. 6. Noise levels in different frequency bands. Measurement points in apartment building environment

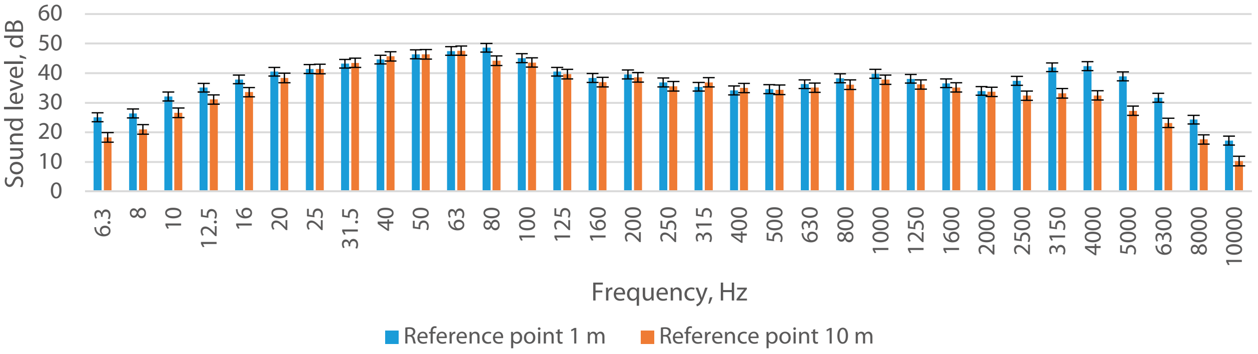

Fig. 7. Noise levels in different frequency bands. Reference measurement points

(8000 Hz – 20000 Hz) noise level was higher at reference point. Difference between these two measurement points at low frequencies on average is 1 dB, at middle frequencies 4 dB and at high frequencies 5 dB.

Noise levels near apartment building were higher at frequency 63 Hz. It could be caused by reflections from the residential apartment building. In all other frequencies noise near apartment building was slightly lower or similar than in measurement point in 1 m distance from the speed table.

Reference measurements (Fig. 7) shown that the increasing distance from the road has influence on traffic noise.

Noise in reference measuring point in 1 m distance from the street is bigger in whole spectrum than in reference point 10 m away from the same street section. Noise 1 m away from street is higher at low and high frequencies, but similar at middle frequencies.

Highest sound levels were near the speed table and at the reference point 1 meter near the same street where speed table has no impact on traffic noise.

Minimum noise level show the minimum sound level recorded during whole measurement, it means that minimum sound level could be described as sound level without traffic noise. Minimum sound level is not regulated in Lithuanian hygiene norms. Minimum sound levels do not differ significantly indifferent floors inside apartment building, difference is equal to 3 dB. Maximum difference of minimum sound level in outside measurement points is 7 dB.

Equivalent sound levels were highest at reference measurement point 1 meter near the street (69 dB) and at measurement point near the speed table (65 dB). These

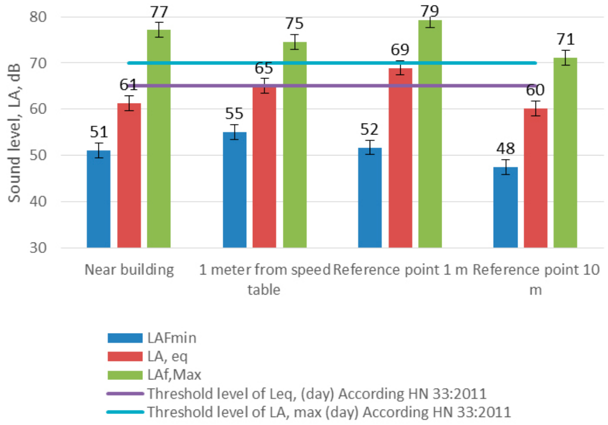

Fig. 8. Minimum, equivalent and maximum noise levels comparison in apartment building environment and reference points

results are higher and equal with noise threshold level in residential building environment in Lithuania, noise level at other measurement points does not reach the threshold noise level. The equivalent sound level is higher at reference point because vehicles run faster in this section of street and the street pavement is bumpy. Equivalent sound level in 10 m reference point was smaller (60 dB). In comparison equivalent sound level at measurement point near the residential apartment building was 61 dB.

Similar study was done by VGTU researchers Akelaitytė and Januševičius. They measured noise induced by different vertical traffic calming measures near the different traffic calming measures. Near the speed table the results of evaluation of their equivalent sound level was around 70 dB. Their measured speed table was made of bricks and this could cause gained higher sound levels than are presented in this paper. Speed table in Asanavičiūtė street is made of asphalt. Similar studies inside the buildings were not found (Januševičius, Akelaitytė 2015).

Maximum sound levels were highest at the same measurement points where equivalent sound level was highest and also in the measurement point near the apartment building. 1 m away from speed table – 74.5 dB, at reference point one meter away from street – 79.2 dB. In comparison of reference point 1 m away from the street and the measurement point 1 m away from the speed table maximum sound level was higher at the reference point, because cars run faster in this section of the street. All maximum sound levels recorded were higher than threshold level in Lithuania. At measurement point 2 m near the apartment building maximum sound level was higher than in reference measurement point 10 m away from the same street. Maximum noise level was higher than threshold level in all measurements.

After measurements inside the building no noise relation was found. These results could show that in different floors there are different apartment building facade characteristics. Small trees are growing near the facade, this could also reduce noise level inside the first floor of the building.

Pavement of L. Asanavičiutės Street in Vilnius is uneven and asphalt is not in a very good condition. Vehicle drivers slow down before the speed table enough to emit less noise than near the reference point. In order to prove this assumption more speed tables in different streets should be studied.

Conclusions

1. Equivalent sound levels were highest at the reference measurement point 1 meter near the street, equal to 69 dB and at the measurement point near the speed table equivalent noise level was equal to 65 dB.
2. When traffic passes through the speed table, the noise at the measurement point which is at 1 m distance from speed table is higher than at the reference measurement point of 1 m. Noise at low frequencies (6.3 – 200 Hz) on average is higher by 1 dB, and at middle frequencies (250 Hz – 6.3 kHz) on average by 4 dB. At high frequencies (8 kHz – 20 kHz) reference point noise on average is higher by 5 dB.
3. The noise relation inside the residential apartment building between different floors was not found. In the first (38 dB) and fifth (41 dB) floor the equivalent sound levels is lower than the threshold sound level (45 dB) according to Lithuanian hygiene norm, but at third floor sound level (45 dB) is the same as threshold sound level.

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GREITĮ MAŽINANČIŲ KALNELIŲ ĮTAKOS TRIUKŠMO SKLIDIMUI GYVENAMAJAME RAJONE TYRIMAI IR VERTINIMAS

T. Astrauskas, R. Grubliauskas

Santrauka

Greičio mažinimo priemonė – dirbtinis kelio (gatvės) dangos nelygumas, skirtas transporto priemonių greičiui sumažinti arba leistinam greičiui palaikyti kelio (gatvės) ruože. Šių įrenginių paskirtis yra sumažinti pavojų pėstiesiems mažinant važiuojančių automobilių greitį. Automobiliai prieš greičio mažinimo priemonę greitį sumažina, pervažiavę ją, dažniausiai vėl didina greitį, todėl transporto keliamas triukšmas gali padidėti. Tyrimai buvo atlikti dienos metu L. Asanavičiūtės g. 5, Vilniuje. Tyrimai buvo išskirti į dvi dalis: tyrimai gyvenamojo pastato viduje ir tyrimai gyvenamojo pastato aplinkoje. Triukšmo lygis prie vertikaliosios trapecinės greičio mažinimo priemonės buvo 69 dB, tiriamojo gyvenamojo pastato viduje apie 41 dB. Šiame straipsnyje yra nagrinėjama greičio vertikaliosios trapecinės greičio mažinimo priemonės įtaka transporto keliamo triukšmo sklaidai į gyvenamąją aplinką.

Reikšminiai žodžiai: transporto triukšmas, vertikalioji trapecinė greičio mažinimo priemonė, gyvenamoji aplinka.