

RESEARCH OF RAILWAY NOISE POLLUTION AT THE LIVING AREA OF RAILWAY STATION IN KLAIPEDA CITY AND DESIGNING OF NOISE BARRIER

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Abstract. Transport, including railways is one of the major sources of noise pollution, having a significant influence for environment and human life. Noise of trains depends on the category of the train, type of rails, train speed and regime of movement (breaking or non-breaking). The level of noise also depends on spinning of wheels as well as moving throughout connections between rails. According to results of this research it is clear that the noise, caused by railway transport at the studied living area is a serious problem, which is necessarily has to be solved with various organizational and technical instruments. It was found that in the living area which is situated 20 meters from rails equivalent and maximum levels of noise are exceeding the limits by 20 dBA. There was found that in average equivalent levels of noise passing passenger trains were 76 dBA and 74–75 dBA passing freight trains, measuring at the distance of 7.5 meters from the rails. At the side of Geležinkelio street the height of noise barrier must be 5–8 meters according to railway line which is being used. For the noise protection of the school which is located at the side of Staciono street the height of noise barrier must be 6–12 meters.

Keywords: railway transport, noise pollution, noise barrier.

1. Introduction

Lithuania has got good expanded system of transport and beneficial geopolitical position. This situation gives an opportunity for Lithuania railways to enter railway transport system of Europe as well as to keep up with changes of international transport market of freight and passengers (Graudinytė 2002; Baublys 2003). Railway transport takes more than 60 percent of land freight market among other transport vehicles (Griškevičienė 2002).

Railway transport is one of the most advantages transport vehicles, which can be used independently of seasons or climatic conditions (Harrison 2004). One of the biggest advantages of this transport – low price. Using train freight transport costs are reduced by one third comparing with other land transport (Baublys 2003).

Noise is concerned with a lot of human activities, but the biggest influence for human life has transport, railway and air transport noise (Lercher *et al.* 1996; Baltėnas and Puzinas 2009). Transport, including railways is one of the major sources of noise pollution, having a significant influence for environment and human life. Since now, there was not enough attention given for this problem. While railway locomotives are being improved, the speed of moving is increased, therefore noise pollution is also amplified (Bazaras and Rutka 2002).

Noisy environment during work and rest time annoys, causes fatigue, reducing attention, slowing psychological reactions, wearing nervous system (Jaskelevičius and Užpelkienė 2008). Noise affects not only hearing, but all human organisms (Stansfeld *et al.* 2000).

Noise of trains depends on the category of the train, type of rails, train speed and regime of movement (breaking or non-breaking). The level of noise also depends on spinning of wheels as well as moving throughout connections between rails (Vér and Beranek 2006; Lietuvos geležinkeliai... 2001).

The contact rail-wheel has a significant influence for the level of noise. Typical noise of rail-wheel contact is caused of each pair of wheels passing rail connections. Noise level depends on type and condition of rails and wheels, type of breaking system, the way of train is connected and axial loading. Critical impact is done by rail connections, quality and the degree of surface deterioration (Rimovskis and Ramonas 2005).

Inside the engines of diesel locomotives the cause of noise is done by moving parts. This noise is dominant while the engine is maximum loaded – moving with acceleration, maximum speed (Mačiulis 2000).

In Western Europe and other countries there is attention given to noise pollution while assessing technical condition of transport vehicles (Vaišis and Januševičius 2009).

Therefore more and more attention is given for noise reducing and isolation (Klibavičius 2003).

The aim of research: to assess levels of noise and to design height and position of noise barrier at the living area of railway station in Klaipeda city.

2. Object and methodology of research

The measuring of railway's noise pollutions is done at the living area of railway station in Klaipeda city.

Levels of noise caused of railway were measured in selectively chosen places. These places are chosen considering how near by railway are living places, also in consideration of passing trains speed.

The railway transport was divided into two categories: passenger trains and freight trains while levels of noise were measured. In each place of measuring were counted the number of wagonloads. When number of wagonloads and time of train's passing measuring place were established, speed of trains can be assessed.

Levels of noise were measured at the distance of 7.5 meters and 20 meters from the rails. At territory near by living buildings levels of noise were assessed in 4 meters height from territory surface.

Results of noise measuring were compared with allowable levels of noise. These levels are determinate in Lithuanian hygiene norm HN 33:2007 "Acoustic noise. Limitary levels of noise in living and public buildings and in their environment". According hygiene norm HN 33:2007, maximum level of noise must not exceed 70 dBA, during day time at living area, during evening time – 65 dBA, during night time – 60 dBA. Allowable equivalent level of noise at living area, during day time is 65 dBA, during evening time – 60 dBA, during night time – 55 dBA.

Measurer of noise should be calibrated using instruction before and after measuring.

Temperature, relative humidity and wind direction has significant impact for noise reduction in atmosphere, but these factors practically don't have big influence for living building, which are at distance of 100 metres from sources of noise (Baltrėnas *et al.* 2007).

There are no any noise measurements executed when snowing, raining, there is fog or wind speed exceeds 5 m/s. While measuring levels of noise, microphone of the measurer is being covered with special wind screen.

Railway noise is being measured while microphone of measurer is aligned perpendicularly to the railway line. Measurements have been taken since the locomotive passes aligned line till the last wagonload.

Railway noise measurement was done using measurer „Bruel&Kjaer 2260“, which is made in Denmark. This instrument is the first class modern sound analyser. This manual instrument is capable to execute all necessary measurements and analysis of noise levels in environment and microclimate at working places. This instrument fulfils the newest standards of noise level measurers IEC 61672 and ANSI, as well as previous standards IEC 60651 and 60804.

„Bruel&Kjaer 2260“ is able to measure an equivalent and wide band noise parameters, also it is capable to register noise of 6,3 Hz to 20 kHz frequency in diapason of one or 1/3 of octave in frequency bands. Measurer is used for A, B, C characteristics of noise to measure. „Bruel&Kjaer 2260“ works with an error of 1.5 %.

In this research an equivalent and maximum noise levels for A characteristics are measured to assess levels of railway noise.

3. Methodology of noise barrier efficiency calculation

Noise barrier is designed to reduce the levels of noise at the living area of railway station in Klaipeda city. Next, there will be calculations of optimal height of noise barrier and efficiency of it done by following methodology.

In the Figure 1 there is a scheme of noise barrier efficiency calculation given.

There are calculation formulas made for reducing the levels of noise according to scheme in Figure 1.

$$a = \sqrt{L_1^2 + (H - H_1)^2}; \quad (1)$$

here: a – distance from source of noise to the top of noise barrier, m; L_1 – distance from source of noise to noise barrier, m; H – height of noise barrier, m; H_1 – height of source of noise, m.

$$b = \sqrt{L_2^2 + (H_2 - H)^2}, \text{ when } H_2 \geq H; \quad (2)$$

here: b – distance from the top of noise barrier to the top of building, m; L_2 – distance from building to noise barrier, m; H_2 – height of building, m.

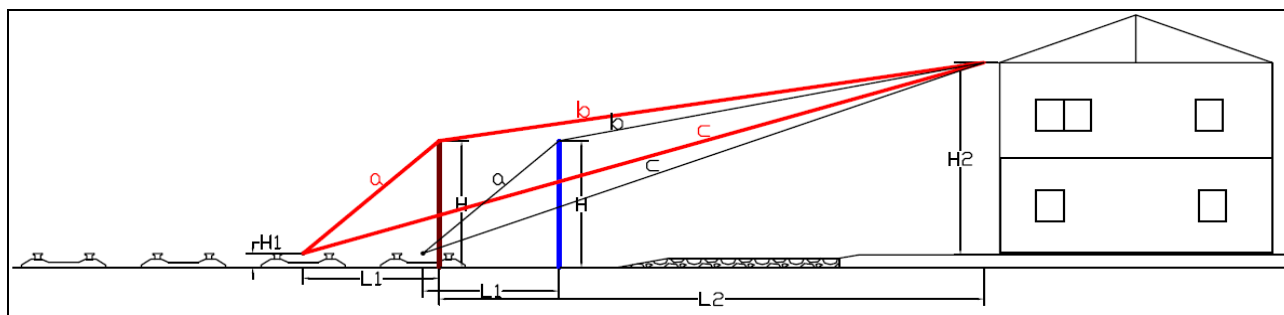


Fig 1. Scheme of noise barrier efficiency calculation: a – distance from source of noise to the top of noise barrier, m; L_1 – distance from source of noise to noise barrier, m; H – height of noise barrier, m; H_1 – height of source of noise, m; b – distance from the top of noise barrier to the top of building, m; L_2 – distance from building to noise barrier, m; H_2 – height of building, m; c – distance from source of noise to the top of building, m

$$b = \sqrt{L_2^2 + (H - H_2)^2}, \text{ when } H_2 \leq H; \quad (3)$$

$$c = \sqrt{(L_1 + L_2)^2 + (H_2 - H_1)^2}; \quad (4)$$

here: c – distance from source of noise to the top of building, m.

$$d = (a + b) - c; \quad (5)$$

here: d – coefficient for level of noise reducing assessment.

There is a chart of correlation between level of noise and coefficient d shown in Figure 2.

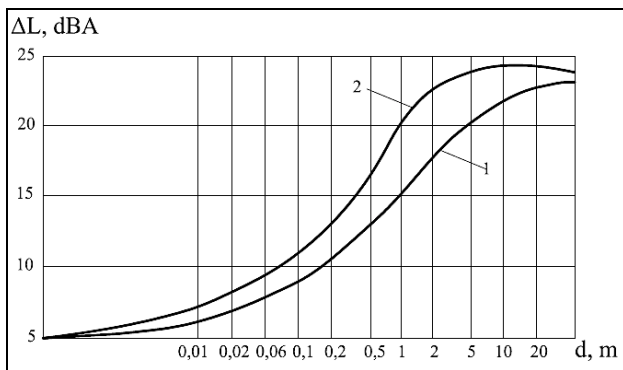


Fig 2. Correlation between level of noise and coefficient d , when 1 – source of noise is linear, 2 – source of noise is stationary-spotted (Заборщикова и Пестрякова 2004).

In this Figure curve number 1 marks the result of correlation when the source is linear; curve number 2 – when the source is stationary-spotted. Coefficient d is founded from formula number 5. When using coefficient d in Figure 2, ΔL can be found. ΔL means level of noise reducing while using scheme number 1 and formulas 1–5.

Efficiency of noise barrier is being calculated while modelling various heights of barrier searching for optimal height, which reduces the level of noise the best.

In modelling process the heights of nearby buildings are set to 6 meters (two floor building) and 12 meters (school building). Distance between the source of noise and barrier is 4 meters or 7.5 meters (if unused first line of railway will not be reassembled).

Using formulas 2-4 coefficients a , b , c were founded. Using formula 5, coefficient d was founded. When all coefficients were founded, by using Figure 2, the efficiency of noise barrier (ΔL) can be estimated.

4. Results of research

In this research it was found that in most cases of all measurements the allowable level of noise created by railway transport was exceeded.

Major reasons for this fact are: absence of noise barriers between railway lines and living areas, construction of living houses at railway sanitary zone, no (windows and walls) refurbishment done for buildings in this zone, condition of train wheels and rails, speed of trains in station approach is too high.

Figure 3 shows the level of noise created by passenger trains at a distance of 7.5 meters from the rails. Values of equivalent noise are ranging between 66 and 86 dBA; maximum noise – between 67 and 89 dBA. At the distance of 7.5 meters from railway there are no any obstructions effecting the spreading of noise, therefore noise levels of railway transport depend on the condition of train wheels and railway, train speed and acceleration.

In Figure 3 it is difficult to find a reliance on the number of wagonloads for the noise created by passenger trains. According to analysis of the level of railway noise it is clear that passenger train with 3 wagonloads creates the level of noise between 66 and 82 dBA; passenger train with 4 wagonloads – between 73 and 86 dBA.

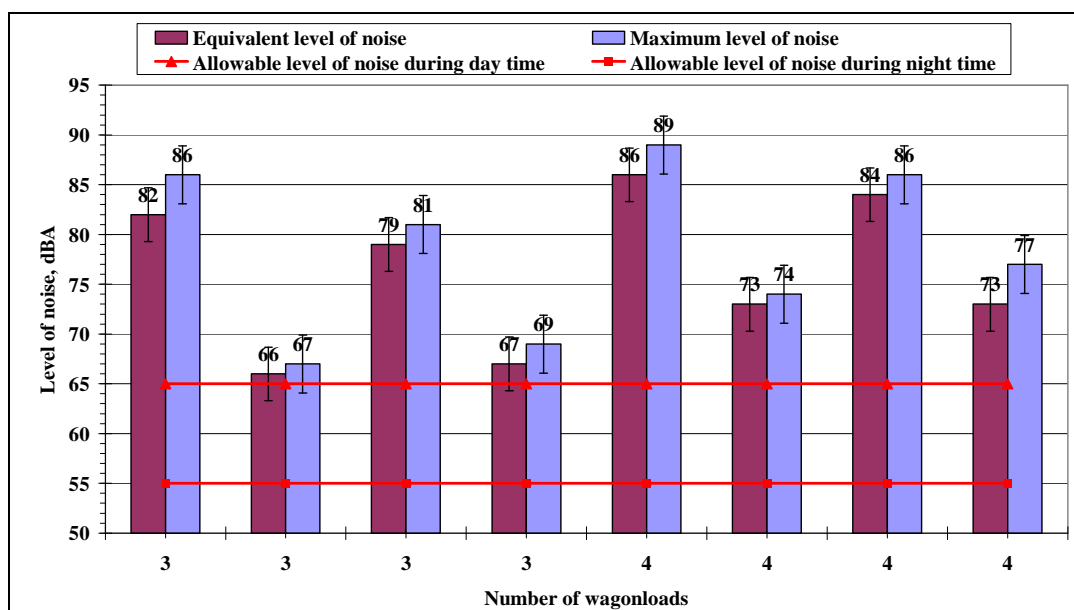


Fig 3. Levels of noise caused by passenger trains at the distance of 7.5 meters from the rails

The speed of passenger trains varies 17–34 km/h at the territory of research. The levels of noise were different due to the way train was moving: out of the station or to the station. The movement of the latter of them was decelerated and generated noise levels of 67–69 dBA. Trains which were moving with acceleration out of the station located at the distance of 1 km from the observed sector, generated noise levels of 73–86 dBA. Main reason for higher noise – maximum engine loads while accelerating.

However at the distance of 7.5 meters from the railway the maximum levels of noise were generated by freight trains. The most of the trains were comprised of the cisterns with oil products of closed type wagons with fertilizer.

Figure 4 describes noise levels of freight trains carrying oil products. These trains generate an equivalent level of the noise ranging in wide diapason 64–92 dBA; maximum levels 75–103 dBA. The reason for this wide

diapason is not only those heavy loaded freight trains are passing this section or empty freight trains are returned to station but also the fact that there are often trains forming works performed. Besides, maximum levels of the noise, approx. 100 dBA are caused by the train sound signals.

While assessing noise levels of trains without sound signals, the maximum equivalent level of noise reached 84 dBA. The speed of this train, comprising of 65 wagonloads, was 23 km/h. It was the highest speed of all freight trains carrying oil products. The rest of the trains carrying oil products were moving at the speed of 10–20 km/h and generated an equivalent noise level of 64–77 dBA at the distance of 7.5 meters from rails.

The following Figure 5 describes noise levels at the distance of 7.5 meters from railway of the freight trains carrying powdery materials. These trains created equivalent noise levels ranging between 61 and 88 dBA; maximum 66–102 dBA.

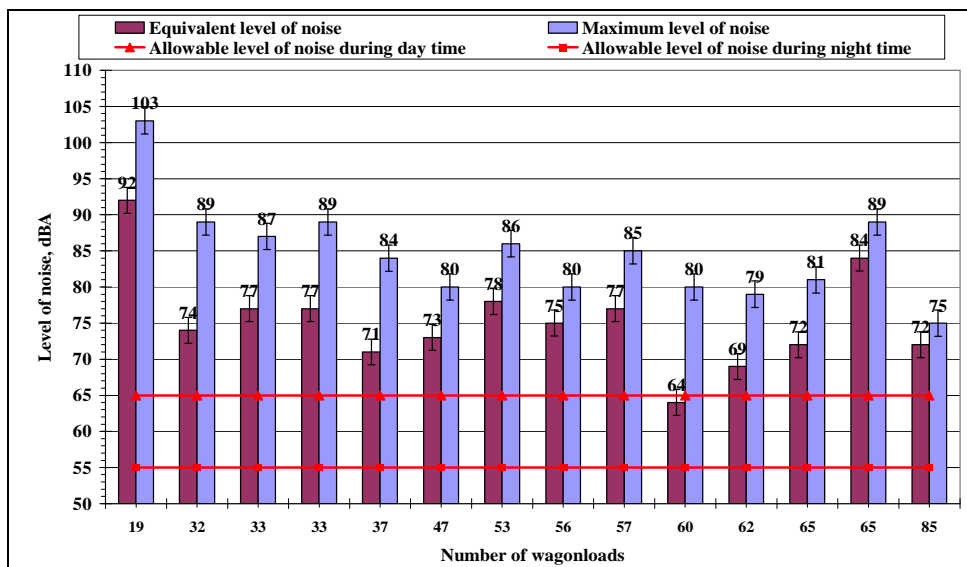


Fig 4. Levels of noise caused by freight trains loaded of oil at the distance of 7.5 meters from the rails

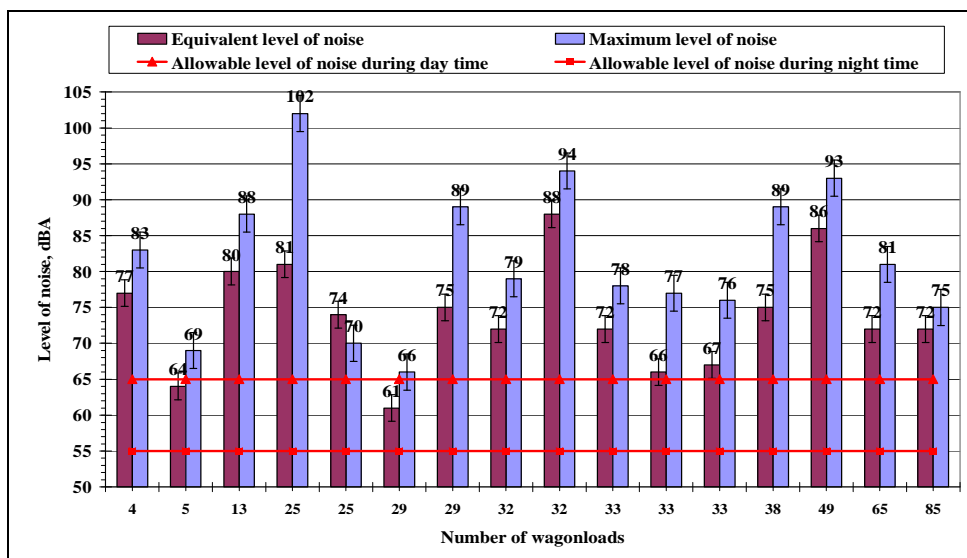


Fig 5. Levels of noise caused by freight trains loaded of fertilizer at the distance of 7.5 meters from the rails

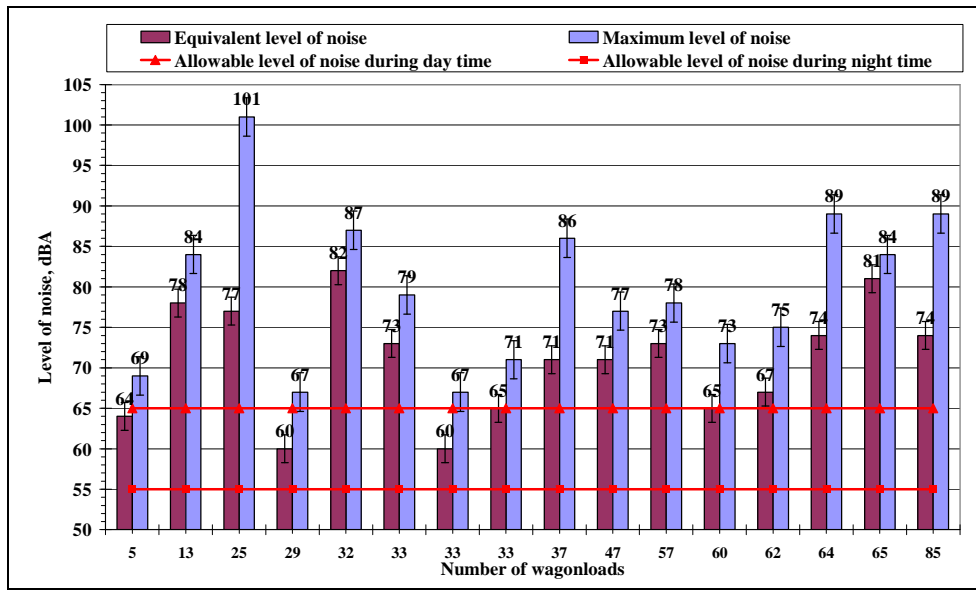


Fig 6. Levels of noise caused by freight trains at the distance of 20 meters from the rails

Table 1. Levels of railway noise were measured at the distance of 7.5 meters from the rails

Level of noise	Average level of noise		Maximum level of noise	
	Equivalent level of noise, dBA	Maximum level of noise, dBA	Equivalent level of noise, dBA	Maximum level of noise, dBA
Passenger trains	76	79	86	89
Freight trains (oil products)	75	85	93	103
Freight trains (fertilizer)	74	82	88	102

Table 2. Levels of railway noise were measured at the distance of 20 meters from the rails

Level of noise	Average level of noise		Maximum level of noise	
	Equivalent level of noise, dBA	Maximum level of noise, dBA	Equivalent level of noise, dBA	Maximum level of noise, dBA
Passenger trains	75	78	84	86
Freight trains (oil products)	72	81	81	89
Freight trains (fertilizer)	70	78	82	101

Minimal noise levels were registered after trains passed at the speed of 8 and 3 km/h, respectively 61 and 64 dBA. Maximum noise level reaching 88 dBA was achieved after freight train at the speed of 26 m/h passed by. This is the reason why it is proposed that higher noise levels are reached with a help of higher train speed.

Figure 6 describes an equivalent and maximum levels of the noise, measured at the distance of 20 meters from the railway in the living area when freight trains passed by. The diapason of an equivalent level of the noise is ranging between 60 and 82 dBA; maximum – between 67 and 101 dBA. This research concludes that levels of the noise spreading from the railway to living area are exceeding the allowable limits (according HN 33:2007) when there are no any barriers between railway and living area.

Tables 1 and 2 describe summarized results of railway noise levels measuring at the distance of 7.5 and 20 meters from rails. Here an average and maximum levels of noise generated by passenger and freight trains are placed.

Maximum in average equivalent levels of noise caused by passenger trains – 76 dBA and by freight trains – 74–75 dBA at the distance of 7.5 meters from rails. The highest equivalent noise level was reached by passing freight train – 93 dBA; passenger train – 86 dBA at the same distance. At the distance of 20 meters from the railway maximum in average levels of the noise were registered when passenger trains passed by. At the living area (20 m away from the railway) the levels of noise triggered by passenger trains in average reached 75 dBA; by freight trains – 70–72 dBA (see Table 2).

According to results of this research it is clear that the noise, caused by railway transport at the studied living area is a serious problem.

The cardinal way to solve this serious problem of disaffection of people towards the noise pollution and vibration caused by railway transport is prohibition of building construction at these typical areas, where it is impossible to guarantee noiseless environment. The most effective method of protecting existing territories and buildings is installing of the noise barriers.

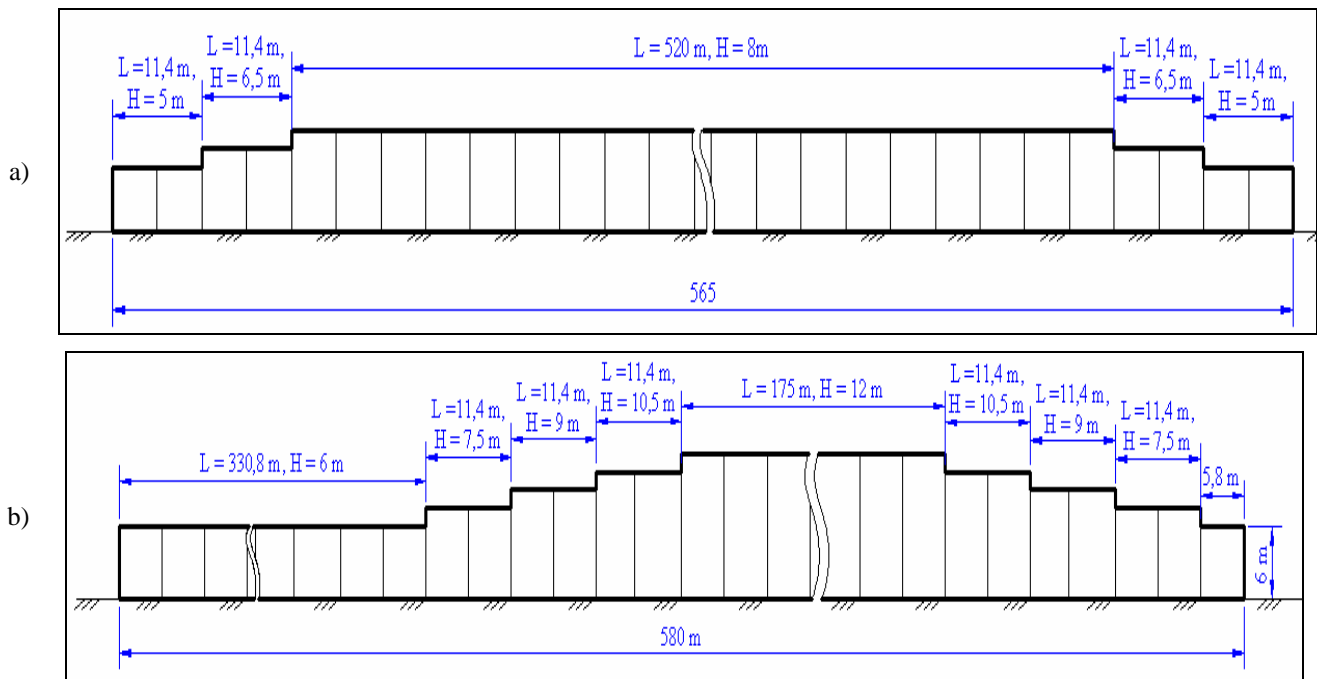


Fig 7. Recommendations for the designing of noise barrier: a – noise barrier recommended in Geležinkelio street; b – noise barrier recommended in Stadiono street (L – length of noise barrier segment, m; H – height of noise barrier segment, m)

5. Designing of noise barrier

It was found that in the living area which is situated 20 meters from rails equivalent and maximum levels of noise are exceeding the allowable levels of noise.

By the calculations at the side of Geležinkelio street the height of noise barrier must be 5–8 meters according to railway line which is being used. There are no assessments done for noise barrier material type or thickness.

For the noise protection of the school which is located at the side of Stadiono street. The height of noise barrier must be 6–12 meters and progressively should go downhill to reach the height of 6–8.5 meters at the living zone.

Recommended heights and lengths of the sections of noise barriers are proposed at Figure 7.

At Geležinkelio street noise barrier is intended to begin with viaduct across H. Manto street. At this location height of noise barrier will reach 5 meters.

To reduce noise at the places near the living area where railway traffic is the most intensive an average noise barrier height of 8 meters is enough. Due to this, maximum offered height to noise barrier is 8 meters, because we accept that all buildings are the same height on this side. Here, at the distance of 4.1 meters from the side railway axis, proposed length of noise barrier is 520 meters. The proposed gradual downhill of noise barrier is displayed at Figure 7a.

The height and length of noise barrier at Stadiono street is given at Figure 7b. This noise barrier is different with it's height comparing to the barrier parallel to Geležinkelio street. Maximum height of noise barrier must be 12 meters. It is recommended to install noise barrier with such height in front of the school building. The length of it – 175 meters. Gradually this noise barrier will

go downhill until 6 meters of height continuing 6 meters in length at Pušyno street (see Figure 7b).

6. Conclusions

1. According to results of this research it is clear that the noise, caused by railway transport at the studied living area is a serious problem, which is necessarily has to be solved with various organizational and technical instruments.
2. It was found that in the living area which is situated 20 meters from rails equivalent and maximum levels of noise are exceeding the limits by 20 dBA.
3. There was found that in average equivalent levels of noise passing passenger trains were 76 dBA and 74–75 dBA passing freight trains, measuring at the distance of 7.5 meters from the rails.
4. There was found that in average equivalent levels of noise passing passenger trains were 75 dBA and 70–72 dBA passing freight trains, measuring at the distance of 20 meters from the rails.
5. At the side of Geležinkelio street the height of noise barrier must be 5 – 8 meters according to railway line which is being used. For the noise protection of the school which is located at the side of Stadiono street the height of noise barrier must be 6–12 meters.

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