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THE TRAFFIC NOISE IN THE VICINITY OF THE TRAFFIC CALMING MEASURES

Abstract

The aim of the study is to analyse and compare the vehicle noise level when driving through the speed bumps and near them. Sound level measurements were taken in selected street cross-sections in Kielce, which are equipped with different types of traffic calming measures. The traffic noise was recorded in one seconds time interval using a manual sound meter. At the same time traffic movement characteristics were being controlled. The vehicle type, driving techniques and the running speed influence elimination allowed to assess the impact of the traffic calming barriers presence and their slowing effect on registered noise values.

Keywords: traffic noise, speed bump, traffic calming measure

1. Introduction

The society pay attention to the state of the acoustic climate in their daily activities area increasingly, nowadays. People want to work and hang out in a very quiet, safe and friendly surrounding for themselves and for the environment. Road users require proper mobility conditions and the proximity of connections at the same time. Travelling by cars instead of walking on foot is being favored in the city centres and in residential areas. Road network designing by forming wide streets cross-sections and long, straight roadways is conductive to attaining high-speed driving. Road users wish to move faster and faster and traffic signs are not enough to persuade them to comply with speed limits [5]. Built-up area valid speed is to 50 km/h, while in the regions where the interweave of pedestrian, vehicle and bicycle traffic occur there are differ limit zones applied: the reduced speed zone, residence zone (up to 20 km/h) and the pedestrian zone [5, 7]. Strongest traffic restrictions are slighted by the drivers most frequently and, thereby, it causes a great danger for the other road users.

In order to ensure safety along thoroughfares, especially near schools, the street cross-sections are often equipped with a safety traffic device. One of possiblities, the most popular and easiest traffic calming measures to apply are speed bumps and speed humps. Protruding barbs form physical obstacles in the road cross-sections. The hindrances effectively limit the vehicles speed [1]. Failure to comply with road conditions may result in damage to the vehicle or low ride comfort, therefore that kind of speed control device is characterized by high efficiency. The effect of speed reduce because of the traffic calming measures existence was show in Figure 1.

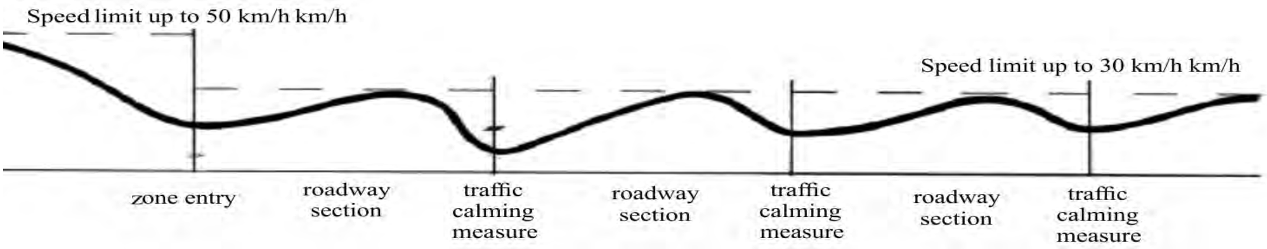

Fig. 1. The process of vehicle speed changes in the traffic calmed zone [4]

Mounting the road impediments is the most reasonable and justified action in terms of safety. Unfortunately, this approach has its drawbacks, too. It is mentioned that the increase in noise level around the obstacles occurs in the first place. The other negative effects include:

- excessive emissions of exhaust gases generated during braking and acceleration maneuvers,
- a threat to cyclists and to the other two-wheeler vehicle drivers passing through the obstacles,
- the need to slow down the emergency vehicles during the intervention,
- difficulties with the exact roadway snow removal,
- difficulties with the exact roadway drainage,
- frequent shoulders and pavements damages by drivers who try to avoid the obstacles [12].

Sound levels research which include the vehicle passages through the bumps that were made in the UK show that the noise is higher in their surroundings [2]. Other data indicate that with the appearance of obstacles the noise around them is reduced for about 10%, despite the frequent shifting and variable vehicle speed in the impact zone [11]. Because of the unclear situation in the influence of vehicles passages through the bumps on the nuisance sounds assessment there was a task related to an attempt to explain the situation undertaken.

2. The assumptions used in own research, research plan

The subject of research in terms of the speed bumps impact on the noise acoustic climate was to record traffic sound during the vehicle passages through the obstacles on the road and during the passages without it. Then, the comparison was made about the results with data collected. Measurements were taken in Kielce, during the sunny, ordinary working day (Thursday), in May 2014. The top surface layer which the vehicle was moving on was dry and in good technical condition. Due to the nature of the analyses, it was found that the most favorable time of the day to the data recording is the off-peak hour. The measurements were taken between 10:00 am and 2:00 pm. The road testing sections selection was based on the various types of obstacles applied on Polish roadways in accordance with the Ordinance [9] and the Provisional Guidelines [10]. The selected street research areas were located inside the housing estates where they could cause an acoustic discomfort for residents of nearby buildings. The attention was given to those street cross-sections, which are equipped with obstacles of different materials and with different heights. The linear slat bumps, linear panel bumps (U-16) and speed humps (U-17) were taken into account in the paper. The obstacles were made of vulcanized rubber, concrete block paving, mineral mix – asphalt, as well as the mixed construction. The mentioned solutions have different speed limits too. Humps type 1, where the recommended passage speed ranges from 25 to 30 km/h and type 2 with a speed limit of 18 to 20 km/h were noted according to [10]. In addition, type 3 that describes the speed humps with recommended speed reduction up to 5 to 8 km/h was assumed.

The research was performed in 5 street cross-sections in Kielce that were equipped with mentioned obstacles. The roadways and traffic calming measures functioning there were illustrated in Figure 2.

The noise was recorded using Extech SDL600 Sound Level Meter/Datalogger which complies with EN 61672-1, accuracy class 2. The following characteristics were set in the measuring device: the A frequency weighting, FAST time response and the desired sampling rate 1 s. Automated and direct method of measure was used. The research was performed at a height of 1.5 m, 1.0 m far from the edge of the road before and that at the obstacles. When the sound was being recorded the vehicle passage and the device display was filmed by the camera also at the same time. By this method, the time of the impact of obstacles on vehicles movement was defined. The investigation allowed the adoption of the comparative intervals to determine the short-term equivalent sound levels. Additionally, the German TA Lärm was very helpful to make the decision of equivalent continuous sound level intervals. Sound measurements were performed during single rides of the same middle class passenger vehicle, driven by the same person.

The vehicle traversed each street cross-section sixteen times. The speed was estimated by the driver as the most advantageous in terms of ride comfort, travel time and technical capacity of the vehicle. Such assumptions led to capture the actual driver behavior situations as close as possible. Two noise parameters were used to realize the analyses:

- equivalent continuous sound levels with fluctuation of 3 and 5 seconds, $L_{Aeq,\,T=3s}$ and $L_{Aeq,\,T=5s}$, calculated in accordance with the procedure concluded in [6, 8];
- maximum sound levels, L_{max}, determined on the basis of video footage from the direct device display observation.

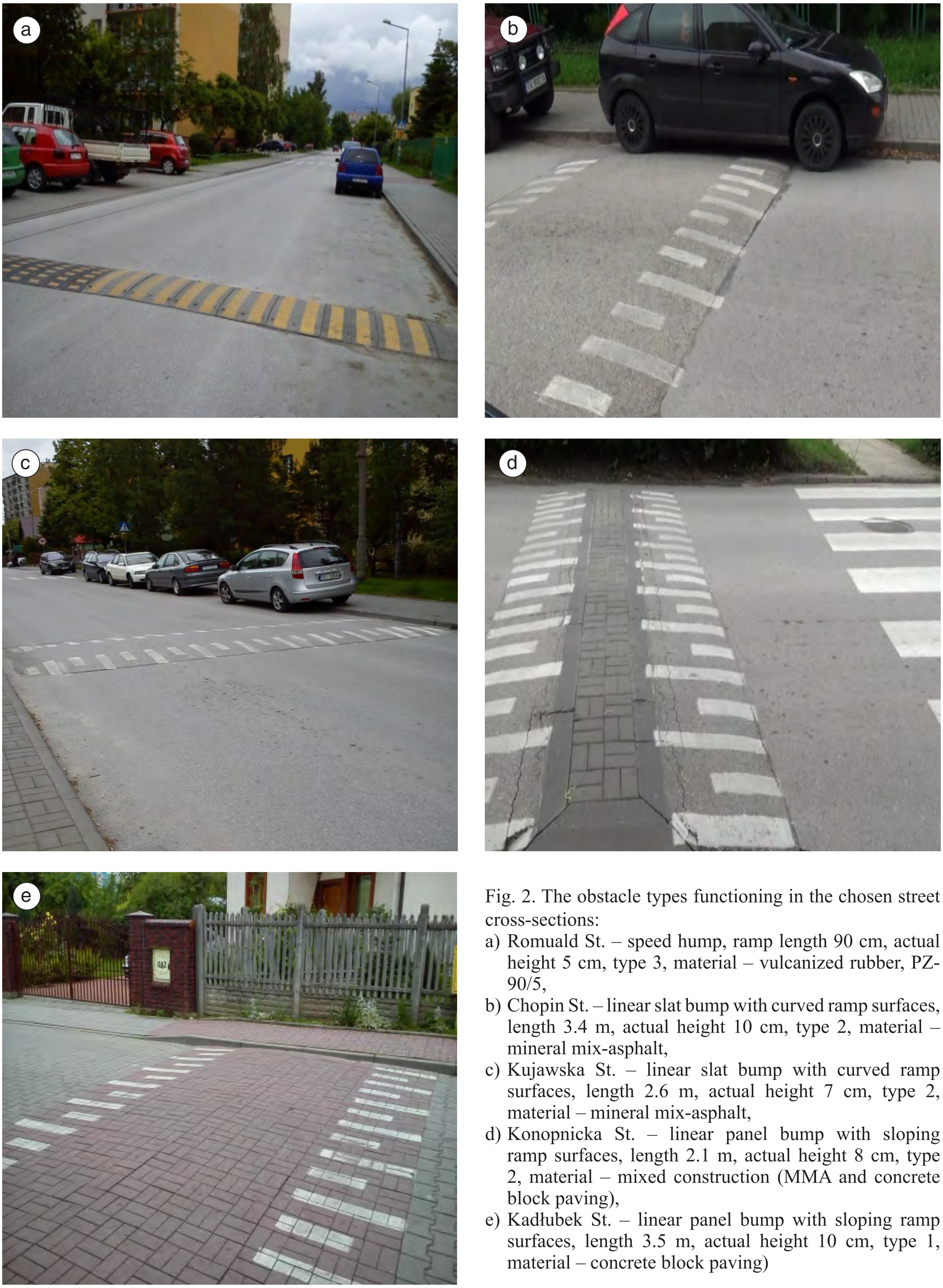

Fig. 2. The obstacle types functioning in the chosen street cross-sections:

a) Romuald St. – speed hump, ramp length 90 cm, actual height 5 cm, type 3, material – vulcanized rubber, PZ-90/5,
b) Chopin St. – linear slat bump with curved ramp surfaces, length 3.4 m, actual height 10 cm, type 2, material – mineral mix-asphalt,
c) Kujawska St. – linear slat bump with curved ramp surfaces, length 2.6 m, actual height 7 cm, type 2, material – mineral mix-asphalt,
d) Konopnicka St. – linear panel bump with sloping ramp surfaces, length 2.1 m, actual height 8 cm, type 2, material – mixed construction (MMA and concrete block paving),
e) Kadłubek St. – linear panel bump with sloping ramp surfaces, length 3.5 m, actual height 10 cm, type 1, material – concrete block paving)

3. The measurement results and the analyses

After data collecting, the systematized information was set together in Microsoft Excel spreadsheet tabular form. Then, the average logarithmic values were determined on the basis of the one second records of sounds that characterized before and at the obstacles vehicle noise. In addition, the analysis of the expanded uncertainty were done. It consisted of type A and type B uncertainty calculation with confidence level of 95% for every acoustic situation [3]. The uncertainty determined was based on the formula 1.

$$U_{R,95}=\sqrt{U_{A,95}^{2}+U_{B,95}^{2}} \qquad (1)$$

where:
$U_{R,95}$ – expanded uncertainty,
$U_{A,95}$ – type A uncertainty associated with the scatter in the measurement results,
$U_{B,95}$ – type B uncertainty associated with the device and measuring procedure.

The one second sound level values with the expanded uncertainty at a confidence level of 95% of the upper and lower deviation were shown in Table 1.

Table 1. One second sound level values and expanded uncertainty

Street cross-section	Time [s]	Logarithmic average values and an expanded uncertainty at a confidence level of 95% and upper and lower deviation	
		before the obstacle	at the obstacle
Romuald	1	59.2 (1.1; 1.4)	58.5 (1.1; 1.4)
	2	61.5 (1.0; 1.3)	62.7 (1.2; 1.6)
	3	63.6 (1.0; 1.3)	64.9 (1.1; 1.5)
	4	65.8 (1.0; 1.3)	67.3 (1.1; 1.5)
	5	67.9 (1.0; 1.3)	70.0 (1.2; 1.6)
	6	69.1 (1.0; 1.3)	71.4 (1.1; 1.4)
	7	67.9 (1.0; 1.3)	70.3 (1.1; 1.4)
	8	66.3 (1.0; 1.3)	66.8 (1.2; 1.5)
	9	63.1 (1.0; 1.3)	61.8 (1.2; 1.5)
Fryderyk Chopin	1	53.7 (1.0; 1.3)	54.7 (1.0; 1.3)
	2	55.3 (1.1; 1.4)	59.5 (1.0; 1.3)
	3	57.6 (1.1; 1.4)	62.8 (1.0; 1.4)
	4	60.3 (1.1; 1.5)	66.3 (1.2; 1.6)
	5	62.7 (1.1; 1.4)	68.5 (1.2; 1.6)
	6	64.1 (1.1; 1.3)	67.9 (1.1; 1.4)
	7	65.3 (1.1; 1.3)	66.0 (1.1; 1.4)
	8	64.7 (1.1; 1.3)	62.4 (1.1; 1.3)
	9	61.1 (1.1; 1.3)	60.1 (1.1; 1.4)
Kujawska	1	53.2 (1.0; 1.3)	54.5 (1.1; 1.4)
	2	55.5 (1.1; 1.4)	58.4 (1.1; 1.4)
	3	58.6 (1.1; 1.4)	61.5 (1.1; 1.4)
	4	61.5 (1.1; 1.4)	64.5 (1.2; 1.6)
	5	64.2 (1.0; 1.3)	66.6 (1.2; 1.5)
	6	65.6 (1.1; 1.4)	67.4 (1.2; 1.6)
	7	65.6 (1.1; 1.5)	66.0 (1.2; 1.6)
	8	63.2 (1.1; 1.5)	62.8 (1.1; 1.5)
	9	59.4 (1.0; 1.3)	59.8 (1.2; 1.6)
Maria Konopnicka	1	54.6 (1.3; 1.8)	54.7 (1.0; 1.3)
	2	56.6 (1.1; 1.4)	57.5 (1.1; 1.4)
	3	59.1 (1.1; 1.4)	59.3 (1.1; 1.4)
	4	61.0 (1.1; 1.4)	61.4 (1.1; 1.4)
	5	63.8 (1.1; 1.4)	63.3 (1.0; 1.3)
	6	65.5 (1.1; 1.3)	65.6 (1.1; 1.3)
	7	65.4 (1.0; 1.3)	66.0 (1.0; 1.3)
	8	61.9 (1.1; 1.4)	63.6 (1.0; 1.3)
	9	58.8 (1.1; 1.3)	59.4 (1.0; 1.3)
Wincenty Kadłubek	1	54.6 (1.0; 1.3)	54.7 (1.0; 1.3)
	2	58.7 (1.0; 1.3)	59.0 (1.1; 1.3)
	3	61.5 (1.0; 1.3)	61.8 (1.0; 1.3)
	4	64.1 (1.1; 1.4)	64.3 (1.0; 1.3)
	5	65.8 (1.0; 1.3)	66.1 (1.0; 1.3)
	6	66.8 (1.0; 1.3)	66.4 (1.0; 1.3)
	7	65.2 (1.0; 1.3)	65.4 (1.0; 1.3)
	8	63.4 (1.0; 1.3)	62.9 (1.0; 1.3)
	9	59.9 (1.0; 1.3)	59.9 (1.0; 1.3)

After the measurement results analyses it can be concluded that the sound level that was recorded before the obstacle is often lower than that noted during the vehicle passing over it. Considering the uncertainty results of the measurements observed noise levels are higher in case of the vehicle passages through the obstacle type 2 and 3. It may be inferred that the greatest acoustic inconvenience appears in the obstacles type 3 (speed humps) equipped road surroundings. The lowest nuisance is caused by the type 1 speed bumps. These kind of obstacle does not require a significant vehicle speed reduction. The highest sound levels were observed at Romuald St. and the lowest at Konopnicka St.

To illustrate the comparison of noise time distribution during the iterative vehicle passes before and at the obstacles of each type the comparative graphs were done. The graphs were shown in Figure 3. In case

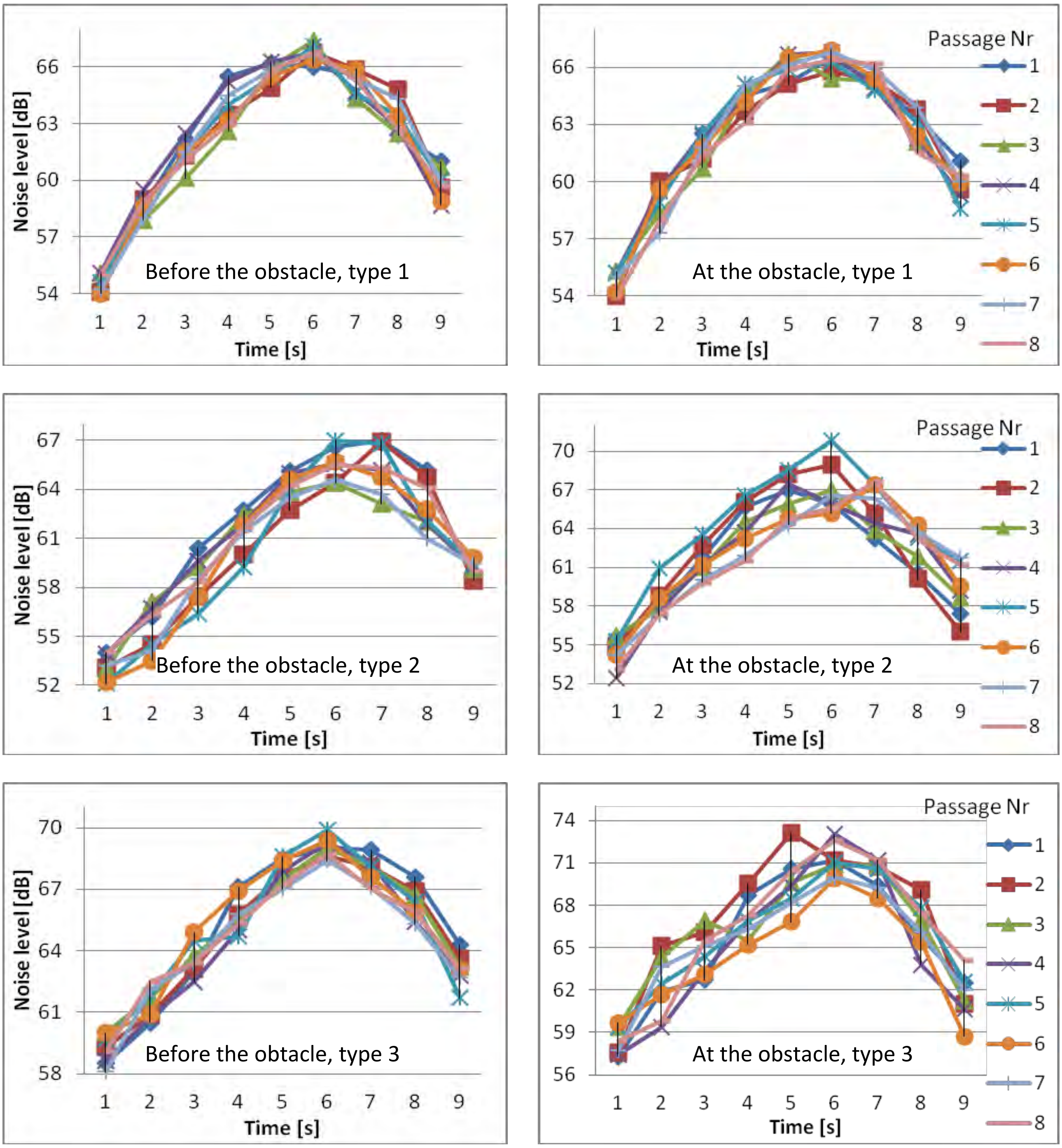

Fig. 3. Comparison of sound levels recorded during a series of passages before and at the obstacles depending on their type

of considering the second type of the speed bumps it can be noticed that the noise time distributions are very similar for each of them, so that to describe the general situation results obtained for Kujawska street cross-section were used.

Basing on the data presented in Figure 3 it can be concluded that the multiple vehicle passages through the types 2 or 3 obstacles caused greater noise differences between the individual rides than in the case of the passages through the type 1 obstacle. Such observations could be explained by a greater extortion by the type 1 obstacles in the vehicle speed. Exact time intervals were also observed so that they match accurately the moments of the vehicle movements before, on and just behind the obstacle. On this basis, time intervals from 5 to 7 and from 4 to 8 second of the measurement were estimated. Chosen data were used to calculate the values of sound level equivalent corresponding to the 3 and 5 seconds and indicated as L_{aeq5} L_{aeq3}. In addition, the maximum sound levels, L_{max} were determined. Received traffic noise results were presented in Table 2.

Table 2. Traffic noise indicators summary in relation to the relevant street cross-sections

Considered st. cross-section	Measuring	L_{aeq3}	L_{aeq5}	L_{max}
Romuald	before the obstacle	68.3	67.6	69.9
	at the obstacle	70.6	69.5	73.1
Chopin	before the obstacle	64.2	63.8	66.0
	at the obstacle	67.6	66.7	70.7
Kujawska	before the obstacle	65.1	64.3	67.0
	at the obstacle	66.7	65.8	70.8
Konopnicka	before the obstacle	65.0	63.9	66.6
	at the obstacle	65.1	64.3	67.0
Kadłubek	before the obstacle	66.0	65.2	66.8
	at the obstacle	66.0	65.2	66.9

The noise indicators – L_{aeq3} and L_{aeq5} were calculated basing on the logarithmic average of multiple measurements. From the data presented in Table 2 it can be observed that the obstacle presence is irrelevant in the Kadłubka street cross-section only. In every other case, the noise indicators are always higher for the moments when the obstacles were exceeded by the vehicle. The shorter the observation time the higher equivalent sound levels. It can be concluded that the greatest acoustic discomfort lasts for 3 seconds only.

4. Conclusions

In conclusions it can be said that the speed bumps and speed humps have an effect on the vehicles noise and they cause acoustic climate changes in their surroundings. Due to the calculated indicators values for the adopted equivalent sound levels the most significant differences between the vehicle acoustic consequences of the passages trough the obstacles were observed for the second and third type of the obstacles. Necessity of large speed reduction at the obstacle results in frequently achieving the required or slightly higher than the required value. At the same time those restrictions contribute to the sudden speedy time compensation just after passing the obstacle. As it turns out the majority of drivers accelerates rapidly just over the obstacles, and these behaviour causes the greatest acoustic discomfort. Passing the speed bump and humps with the appropriate speed contributes to a slight increase in the measuring device indications. It is also noted that the obstacles construction is significant. Driving through the sloping ramp surface obstacles causes less nuisance, while the noise in the vicinity of curved ramp surface obstacles is greater. It was assessed also that the obstacle material is hardly relevant and it makes any differences in the sound recorded values.

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Hałas drogowy w pobliżu środków uspokojenia ruchu

1. Wprowadzenie

W celu zapewnienia bezpieczeństwa wzdłuż ciągów drogowych, szczególnie w pobliżu szkół, ulice często wyposaża się w urządzenia bezpieczeństwa ruchu drogowego. Jednym z możliwych, a zarazem najpopularniejszych i najprostszych do zastosowania środków są progi zwalniające. Wystające garby stanowią fizyczną przeszkodę w przekroju poprzecznym drogi. Skutecznie ograniczają prędkość pojazdów, które przez nie przejeżdżają. Niedostosowanie się do warunków panujących na drodze skutkuje uszkodzeniem pojazdu lub niskim komfortem jazdy, dzięki czemu progi charakteryzują się dużą skutecznością. Montowanie poprzecznych progów na jezdni często jest przyczyną skarg mieszkańców pobliskich budynków, którzy narzekają na większy hałas. Z drugiej strony przeszkody ograniczają prędkość przejazdu pojazdów, co powinno redukować hałas. W związku wątpliwościami podjęto działania związane z próbą wyjaśnienia faktycznej sytuacji.

2. Założenia przyjęte do badań, wyniki pomiarów i ich analiza

Wyróżniono progi zwalniające typu 1 i typu 2 oraz podrzutowe typu 3, różniące się ograniczeniem prędkości przejazdu. Badania wykonano w 5 przekrojach ulicznych w Kielcach wyposażonych w różne rodzaje przeszkód. Hałas rejestrowano za pomocą decybelomierza Extech SDL600, który odpowiada normie EN 61672-1, klasa dokładności 2. Wykorzystano metodę sekundowych, automatycznych pomiarów bezpośrednich. Pomiary wykonano podczas szesnastu przejazdów na przekrój, tego samego pojazdu osobowego średniej klasy, kierowanego przez tę samą osobę. Prędkość była szacowana przez kierowcę jako najkorzystniejsza pod względem wygody jazdy, czasu podróży i możliwości technicznych pojazdu. Każdy przejazd wraz ze wskazaniami na wyświetlaczu urządzenia był dodatkowo filmowany. Do wykonywania analiz posłużono się parametrami hałasowymi, takimi jak: równoważny poziom dźwięku ($LA_{eq,T=3s.}$ oraz $L_{Aeq,T=5s}$), maksymalny poziom dźwięku (L_{max}). Dodatkowo pomocne były obliczenia wartości średnich logarytmicznych wraz z niepewnością rozszerzoną na poziomie ufności 95%.

3. Wnioski

Na podstawie wykonanych analiz można stwierdzić, że progi zwalniające i podrzutowe mają wpływ na hałaśliwość przejazdów pojazdów i powodują zmiany klimatu akustycznego w ich otoczeniu. Z uwagi na wyznaczone wskaźniki dotyczące równoważnych poziomów dźwięków największe różnice między skutkami akustycznymi przejazdów pojazdu przed oraz na progach stwierdzono w przypadku przeszkód 2 i 3 typu. Zaobserwowano, że większość kierowców gwałtownie przyspiesza zaraz za progiem, co powoduje największy dyskomfort akustyczny. Sam przejazd przez próg z odpowiednią prędkością powoduje nieznaczny wzrost wskazań urządzenia pomiarowego. Im krótszy czas obserwacji tym wartości L_{aeq} są wyższe. Można więc stwierdzić, że największy dyskomfort akustyczny trwa do 3 sekund. Zauważono również, że konstrukcja progu jest istotna. Przejazd przez progi ze skośną powierzchnią powoduje mniejsze uciążliwości, natomiast hałas w otoczeniu przeszkód podrzutowych oraz tych z łukowymi powierzchniami najazdowymi jest większy. Oceniono również, że materiał, z którego wykonano przeszkody raczej nie powoduje różnic w rejestrowanych wartościach dźwięku.