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THE ACOUSTIC CLIMATE AT THE REST AND SERVICE AREAS – PARKING LOTS BY THE SILESIAN SECTION OF A4 MOTORWAY

Summary. The aim of this article is to describe the state of the acoustic climate at the rest and service areas (MOPs) situated by A4 motorway in Silesia The analysis includes the research results conducted at these parking lots from May till August 2010. The research was conducted with the digital noise meter, which was connected with the computer during measurement. The research results indicate the essential differences in the noise intensity between the particular rest and service area reaching up to 12 dB(A), in spite of the similar value of the traffic noise in all of the places where the research was conducted. It was assumed that the level of noise on each of the parking lots should be similar to standing norms for the recreation areas i.e. below 55 dB(A). The research conducted at 4 MOPs indicated that only at two of them, MOP Halemba and Wirek, these norms are fulfilled. The lack of the proper anti-noise protection in the form of the sound absorbing screens at the parking lots situated by the motorway causes the situation in which the level of noise at the places devoted to rest highly decreases the possibility to relax before the next stage of a journey.

KLIMAT AKUSTYCZNY W MIEJSCACH OBSŁUGI POJAZDÓW NA PARKINGACH PRZY ŚLĄSKIM ODCINKU AUTOSTRADY A4

Streszczenie. W artykule opisano stan klimatu akustycznego w Miejscach Obsługi Pojazdów usytuowanych przy autostradzie A4 w województwie śląskim – MOP Wirek, MOP Halemba, MOP Proboszczowice, MOP Chechło. Analiza obejmuje wyniki badań przeprowadzonych na tych parkingach w okresie od maja do sierpnia 2010 roku. Badania przeprowadzono przy użyciu cyfrowego miernika hałasu, podłączonego w trakcie pomiarów do komputera. Wyniki badań wskazują na istotne różnice w wielkości natężenia hałasu pomiędzy poszczególnymi Miejscami Obsługi Pojazdów, dochodzącego do 12 dB(A), pomimo podobnej wartości hałasu komunikacyjnego we wszystkich punktach badawczych. Przyjęto, że na każdym parkingu poziom hałasu powinien być zbliżony do obowiązujących norm dla terenów rekreacyjnych, tj. poniżej 55 dB(A). Przeprowadzone badania na 4 MOP-ach wykazały, iż tylko na dwóch z nich normy te są spełnione dla: MOP Halemba i MOP Wirek. Brak odpowiedniej ochrony przeciw-

dźwiękowej w postaci ekranów akustycznych na parkingach położonych przy autostradzie skutkuje tym, że poziom hałasu w miejscach przeznaczonych do wypoczynku znacznie obniża możliwość odprężenia przed dalszą podróżą.

1. INTRODUCTION

Nowadays noise is considered the biggest danger for human natural environment. Among different kinds of pollution, noise is very common and has a lot of sources. The effects of the noise influence on human life are not always noticed right away, that is why noise is often underestimated, and sound absorbing screens are built only in places where the noise intensity is far beyond the acceptable norms [1]. There are a lot of definitions of noise, but the most commonly mentioned definition is that by Z. Engel, I. Malecki and J. Sadowski: "noise is every undesirable, unpleasant, importunate or harmful mechanical vibration of the elastic medium, influencing by means of air on human hearing and other senses and parts of the body" [2]. One of the main elements considered as the crucial source of stress in city areas and outside them is traffic noise. The constantly rising density of car traffic together with the old methods of technical road solutions and, at the same time, the horrible condition of the roads form the main causes of the rise of noise danger in cities and areas surrounding the roads [3 - 5]. Nowadays, with the expansion of the road infrastructure, for example motorways and expressways, many of the places such as petrol stations and parking lots appear next to those roads. It often happens that those places are not sufficiently protected against noise, which is why the workers in such places and the drivers resting on the parking lots are in danger of the excessive influence of the noise level. In this paper some of those aspects are discussed. Although the problem of noise in residential areas and the analysis of it were conducted and described in various papers [6, 7], the problem of noise measurements on parking lots is hard to be found in any of the specialized scientific publications devoted to the problem of noise. Measures were taken to conduct such a research to determine the level of the traffic noise on parking lots called MOPs (Miejsce Obsługi Podróżnych – Rest and Service Areas) by the motorway A4 in Silesian voivodeship – MOP Wirek, MOP Halemba, MOP Chechło and MOP Proboszczowice.

2. MOPs (Rest and Service Areas)

MOP is an area - separated from the main road – where parking lots for the cars and all the facilities for travellers can be found. MOPs in Poland are divided into three categories [8]:

a) MOP category 1 - serves relaxation purposes, has a parking lot, manoeuvring roads, resting equipment, sanitary arrangements, lighting; possible and allowed small gastronomic points

b) MOP category 2 - serves a relaxation and service function: has the objects mentioned in category 1 and a petrol station, car service lots, gastronomic facilities and shops, tourist information.

c) MOP category 3 - serves a relaxation and service function: has places mentioned in category 2 together with accommodation for visitors and if needed a post office, bank, travel agencies or insurance agencies.

MOP Wirek and MOP Halemba share category 2/3 while MOP Chechło and MOP Proboszczowice have category 1. Toilets with shower cabins, toilets for the disabled and places to change a baby's napkin were built there. Moreover, each of MOPs was equipped with traveller resting objects (benches, tables, roofing) and the greenery was arranged.

The terrain was estimated for the needs of small gastronomic points on the MOP category 1 and some area is reserved for this purpose, while in another of the areas MOP category 2/3, the areas devoted to build the infrastructure according to categories of among others petrol stations, gastronomy, motels and other travellers services were marked on plans. In each of MOP category 1, there are [8]:

a) parking lots for passenger cars 50-60 places

b) parking lots for lorries and buses 17-20 places

c) toilets: 5 for females, 3 cabins and 3 urinals for males
d) one toilet for the disabled

In every MOP place category 2/3 there are:
a) parking lots for passenger cars 70-90 places
b) parking lots for lorries and buses 30-40 places
c) toilets 6 for females, 5 cabins and 4 urinals for males and one toilet for the disabled respectively
d) 2 posts for vehicles with dangerous load

3. MEASUREMENT METHODS

Measurement was conducted on the parking lots by the Silesian part of motorway A4 in the area of Ruda Śląska (MOP Wirek and MOP Halemba) and in the locality of Chechło and Proboszczowice (MOP Chechło and MOP Proboszczowice). In the fig. 1 we can see the places of conducted measurement.

Fig. 1. Places where measuring was conducted: a) MOP Proboszczowice, b) MOP Chechło, c) MOP Halemba, d) MOP Wirek
Rys. 1. Miejsca pomiarowe: a) MOP Proboszczowice, b) MOP Chechło, c) MOP Halemba, d) MOP Wirek

The first measurement point was situated according to obligatory law rules connected with the measurement of the traffic noise [9÷14] in the distance of 1.5 m from the edge of the road. The other measurement points were situated in the further distance according to the ground shape of MOP parking lot and its surrounding. In each of these places, the measuring instrument was at the height of 1.2 m above the road surface. Such a placement was chosen to show which level of the noise the people taking rest on the parking lot are exposed to. The placement of the measuring instrument was in accordance with the recommendation issued in the norm [9÷14].

MOP situated by A4 motorway (in Wrocław direction) near the Proboszczowice was chosen as the first research place. There are neither sound absorbing screens nor the embankments decreasing the level of noise.

In addition, the level of the road surface is situated higher than the parking lots. The area behind the parking lot is woody on its whole length. In this part of the motorway there are two traffic lanes in one direction and a shoulder. There are neither apartment buildings nor factories in this place.

MOP near Chechło was chosen as the second place of measurement. Traffic on the road next to the MOP occurs on two lanes in the direction of Krakow. The parking lot and the road are divided by an embankment, which serves as sound protection role. Similarly to the first area mentioned above, the terrain behind the parking lot is woody on its whole length. Also there are neither apartment buildings nor factories there.

MOPs situated on the both sides of A4 motorway in the area of Ruda Śląska were pointed as the third and the fourth research places. The parking lot adjoining the traffic lanes in Wrocław direction is separated from the road by the embankment and in the close distance to its edges there is the detached houses settlement and a workshop. It was pointed as the third research place in Ruda Śląska-Wirek. The road directly adjoining this parking lot has three traffic lanes in one direction.

The parking lot situated on the other side of the road was pointed as the fourth research place in Ruda Śląska-Halemba. The road directly adjoining this parking lot has three traffic lanes in Kraków direction. Between this road and the parking lot there is no embankment but the parking places are situated higher than the level of the road surface. At the end of the parking lot there is a high grassy slope, on top of which grows a forest. There are no estates or factories on this side of the road. MOPs situated in Ruda Śląska were joined by a foot-bridge, which enables walking freely above the motorway from its one side to the other. The entrance on the foot-bridge is a slope with stairs on it and a driveway for people with disabilities. Only in case of MOP Wirek does the slope forming the entrance on the foot-bridge separates partly the parking lot from the road. In the fig. 2-5 the terrain relief for each MOP mentioned above, where research was conducted.

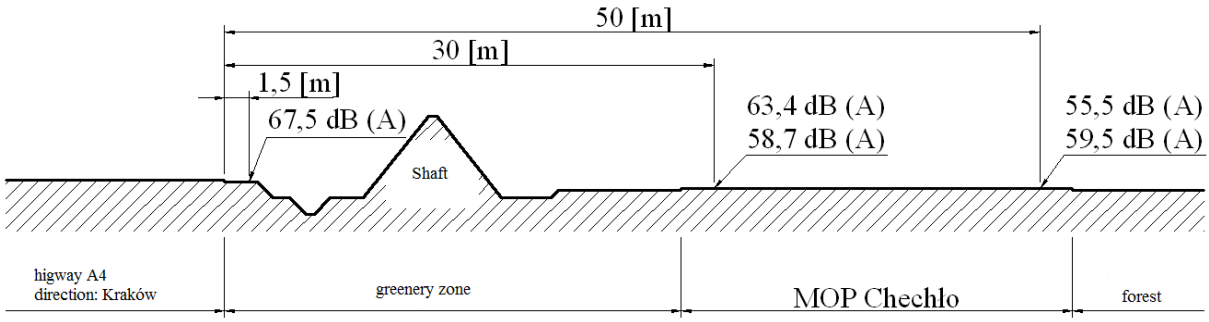

Fig. 2. Soil profile of the terrain MOP Chechło
Rys. 2. Ukształtowanie terenu na MOP-ie Chechło

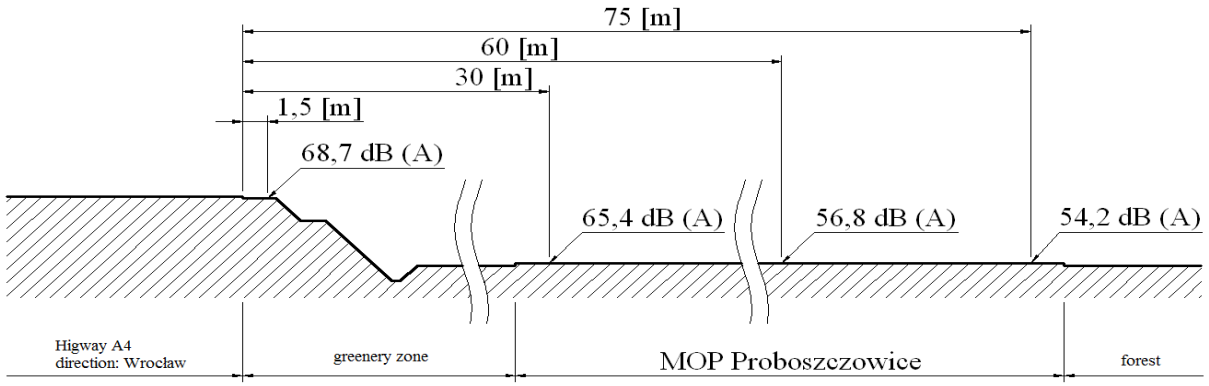

Fig. 3. Soil profile of the terrain MOP Proboszczowice
Rys. 3. Ukształtowanie terenu na MOP-ie Proboszczowice

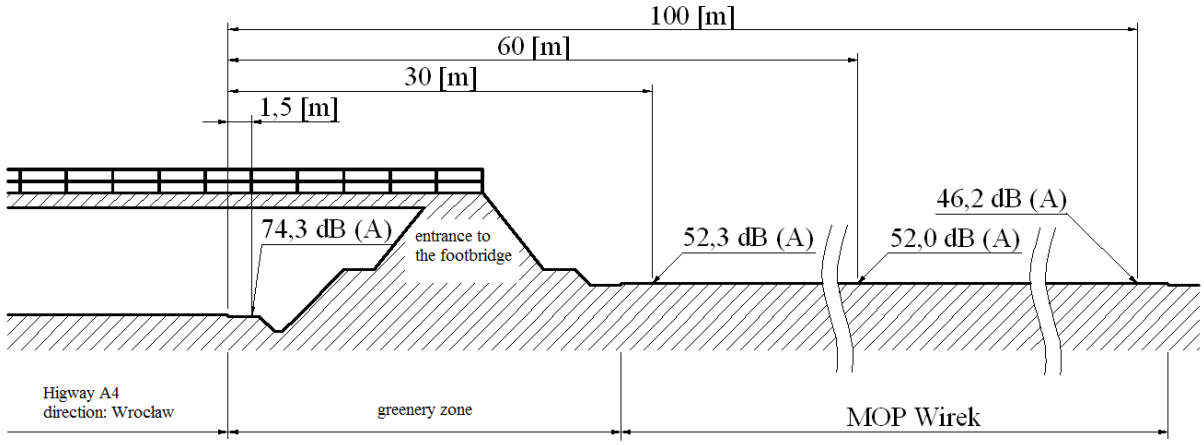

Fig. 4. Soil profile of the terrain MOP Wirek
Rys. 4. Ukształtowanie terenu na MOP-ie Wirek

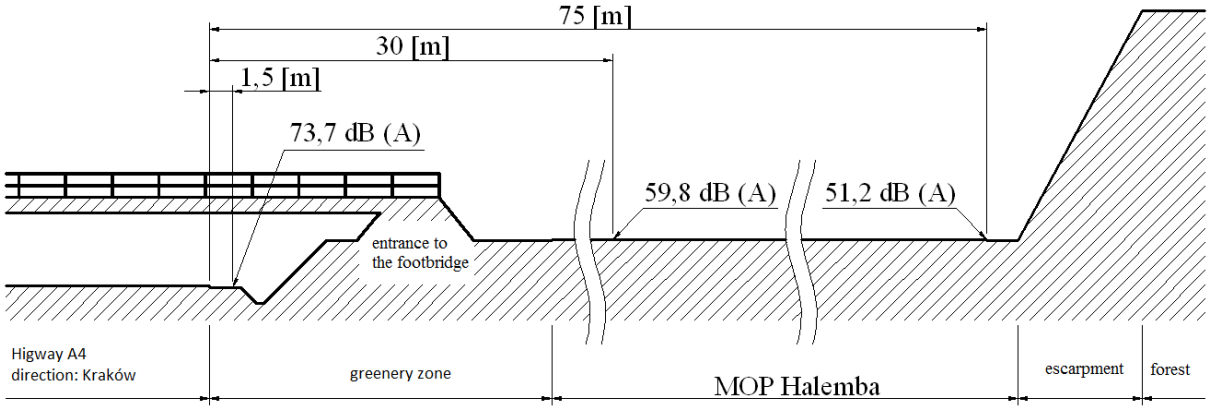

Fig. 5. Soil profile of the terrain MOP Halemba
Rys. 5. Ukształtowanie terenu na MOP-ie Halemba

In order to conduct measurement a AZ8921 meter with special software was used. It enables the continuous recording of sound levels, determining the value of the maximum and the minimum and stating the mean value of the measurements. The view of the program window during measurement is shown on fig. 6.

Taking into consideration the preliminary measurement, conducted in marked points of research, the range of the measuring device was set between 50 to 100 dB(A). In each point of measure a representative period of time was assumed. The period included these hours, when the traffic composition does not differ from one another in more than 25%. Additionally, the participation of noisy vehicles could not exceed 10%. That is why during tests the measurement of the traffic combustion was conducted on the highway and on the parking lots with the division to particular types of vehicles. Research was conducted both at daytime and at night between 8 a.m. and 4 p.m. and between 8 p.m. and 4a.m. The time range was chosen on the basis of previous observations, due to which it was concluded that these are the hours when the parking lots are the most congested. During daytime among the vehicles the biggest amount constituted of private cars and coaches. At night the lorries and delivery cars were in majority. The research was conducted in the summer, so one may assume that in the daytime people visiting the parking lot were travelling on holidays, and at night the majority of the delivery cars and lorries may suggest that the professional drivers of such vehicles are

obliged to rest. Each professional driver is obliged to rest during the journey. The detailed regulations are defined by law and state that the driver should rest not shorter than half an hour, in case when the whole time of driving is between 6 and 8 hours, and should rest not shorter than 45 minutes if the time of journey exceeds 8 hours a day. The intervals can be divided into shorter periods, which are used by the driver in due driving time according to the driving schedule, on condition that one of those intervals is not shorter than 15 minutes. In every 24 hours a driver has the right to 11 hours of uninterrupted rest. The due rest period for a 24-hour day can be used up in the vehicle, if the vehicle stands on a parking lot and has a place to sleep in it. In each working week a driver should spend a period of 35 hours on uninterrupted rest [15, 16].

4. APPLIED METHOD OF THE EQUIVALENT NOISE LEVEL DETERMINATION

Noise generation by car vehicles is mostly a stochastic, non-stationary process. The changeability of the noise level in a given point is dependent on many factors. Among them there are: the intensity and structure of vehicle traffic, speed and technical condition of vehicles, weather conditions, type and condition of the road surface, the character of land development around the road.

Communication parameters have deciding influence on the acoustic conditions appearing in the nearest neighbourhood of the communication roads. Due to that fact, the equivalent noise level LAq T for reference time T (16 hours during the day or 8 hours at night) was defined on the basis of measurements conducted for so-called representative test intervals tri, assumed on the basis of analysis of traffic combustion changes, for which [17]:

$$T = \sum_{i=1}^{n} t_{ri} \ , \tag{1}$$

where: t_{ri} – i representative period, (h) according to a formula:

$$L_{AEqT} = 10\lg\left(\frac{1}{T}\sum_{i=1}^{n} t_{ri}\right)10^{0,1\,L_{AEqt_{ri}}} \ , \tag{2}$$

where: L_{AEqtri} – equivalent noise level marked for i – representative period t_{ri} (h).

5. THE RESULTS OF THE MEASUREMENTS

A specification of the collected results of the level of noise intensity in reference to 8-hour-time in each of the research points is presented in tables 1-4. Statistic evaluation of those measurements was also conducted.

Table 1

Detailed analysis of the research results for MOP CHECHŁO

MOP CHECHŁO	1.5 m	25 m	25 m behind the screen	35 m	35 m behind the screen
$L_{AEq,\ 16\ h}$ [dB(A)]	67,48	63,39	58,68	55,48	59,46
mean error	0,20	0,12	0,09	0,13	0,12
standard deviation	6,5	3,86	2,93	2,18	3,62
sample variance	42,27	14,93	8,6	4,73	13,14
$L_{A\ min}$ [dB(A)]	49,7	53,8	51,4	51	51,2
$L_{A\ max}$ [dB(A)]	83,8	76,5	81,2	62	70,9

Example values of the temporary noise level intensity in researched point of MOP Proboszczowice were shown in the fig. 7. As it can be viewed in the presented characteristics, the noise intensity is much smaller the further you go away from the road.

Table 2
Detailed analysis of the research results for MOP PROBOSZCZOWICE

MOP PROBOSZCZOWICE	1.5 m	30 m	55 m	65 m
$L_{AEq,\ 16\ h}$ [dB(A)]	68,67	65,39	56,77	54,17
mean error	0,22	0,1	0,09	0,07
standard deviation	7,03	3,34	2,95	1,97
sample variance	49,4	11,13	8,67	3,89
$L_{A\ min}$ [dB(A)]	52,3	54,8	50,4	47,8
$L_{A\ max}$ [dB(A)]	96,2	75,8	73,8	60,1

Table 3
Detailed analysis of the research results for MOP Ruda Śląska WIREK

MOP RUDA ŚLĄSKA WIREK	1.5 m	30 m	60 m	100 m
$L_{AEq,\ 16\ h}$ [dB(A)]	74,28	52,33	51,98	46,22
mean error	0,13	0,1	0,22	0,09
standard deviation	4,27	3,11	5,43	2,07
sample variance	18,2	9,7	29,5	4,29
$L_{A\ min}$ [dB(A)]	62,8	44,9	42,8	40,5
$L_{A\ max}$ [dB(A)]	85,2	73,1	67,6	60,6

Table 4
Detailed analysis of the research results for MOP Ruda Śląska HALEMBA

MOP RUDA ŚLĄSKA WIREK	1.5 m	30 m	75 m
$L_{AEq,\ 16\ h}$ [dB(A)]	73,75	59,77	51,24
mean error	0,22	0,17	0,1
standard deviation	5,04	3,85	2,47
sample variance	25,44	14,81	6,1
$L_{A\ min}$ [dB(A)]	55,4	52,4	42,5
$L_{A\ max}$ [dB(A)]	86	76,7	58,3

Equivalent level of communication noise LAEq 16 h, that is measured 1.5 m from the road in accordance to the eight-hour time, in each of the measurement points equal the level higher than 67 dB(A).

The lowest measured of LAEq 16 h of the traffic noise intensity was 67,4 dB(A) and it was received in the point of MOP Chechło. The highest result was received during the measurement in the point of MOP Ruda Śląska Wirek and it was 74,2 dB(A). Such a significant difference, which equals almost 7 dB(A), was caused by the higher traffic intensity on the part of the motorway near Ruda Śląska. Equivalent level of communication noise LAEq 16 h in the point of MOP Proboszczowice was similar to the point of MOP Chechło and equalled 68,6 dB(A). The result of LAEq 16 h received in the point of MOP Ruda Śląska Halemba was only a little bit lower than the one received in the point of MOP Wirek and equalled 73,7 dB(A). The measured values of the traffic noise were similar because these parking lots are situated opposite to each other on the sides of the road and due to this fact the traffic intensity was the same.

Research conducted in second measuring positions, which were situated 30 m away from the edge of the road in other MOP points showed, that the highest result was measured in Proboszczowice 65 dB(A) and the lowest value LAEq 16 h was noticed in MOP Wirek and was 52 dB(A). The noise intensity for MOP Halemba was 59 dB(A) and for MOP Chechło 63,3 dB(A) in a point where no sound absorbing screen was present and 58 dB(A) for a point behind the sound absorbing screen. Such comparison of the results shows how important the right location of the parking lots is, and also what role the protection against noise has. Despite the higher level of traffic noise on the motorway by the parking lots in the area of Ruda Śląska and Proboszczowice, the noise intensity on the parking lot itself was lower. One of the causes is the fact, that parking lots in Ruda Śląska(Wirek i Halemba) are located higher than the level of the motorway. Additionally between the road and the parking lot there is an artificial embankment. Such a form of the built-up area has shown the effectiveness in protection against noise. In MOP Chechło the parking lot is placed on the same level as the road surface, but in the middle of the distance between the road and the parking lot there is an embankment, which serves the role of an acoustic screen. Taking the results into consideration we can conclude that the construction of the acoustic screen caused the reduction of noise intensity by about 5 dB(A). The problem is that the screen is protecting only half of the parking lot and is located in a trough, and that causes a considerable decrease of its effectiveness. The worst acoustic climate situation can be observed in MOP Proboszczowice. This parking lot is situated lower than the motorway. Additionally, between the parking lot and the road there is only a green belt covered with grass, with no trees or bushes. Such a construction of the MOP causes that the noise intensity 30m from the road is only 3,5 dB(A) lower than by the road edge. One should point out here that the noise level in the points 30 m away from the road on all parking lots is monotonous, what is confirmed by the standard aberration on the level of 3,5.

Third points of measurement were placed in MOP Wirek and MOP Proboszczowice 60 m away from the road edge, and in case of MOP Halemba 75 m away from the road edge, and because of the small area of MOP Chechło parking lot, this point was set 50m away from the road edge. The lowest noise level was achieved in MOP Wirek and MOP Halemba and was 51,5 dB(A). The highest level of noise was noted in MOP Chechło, and was 59,5 dB(A), and the value noted in MOP Proboszczowice was 56,5 dB(A). The problem with measurement in such a distance away from the road edge is the influence of the cars moving on the parking lot itself. Additionally on all the MOPs the first parking lot places looking from the road are the places for delivery cars, lorries and vans. They serve an acoustic barrier of a sense for the passenger vehicles, the parking lots for which are placed further from the road edge. It needs to be pointed out that before one sets off to continue the journey in a delivery vehicle, the car need to have the engine "heated up", and sometimes also the refrigerator lorries have switched on devices in the vehicles, what results in the temporary increase of the noise level on the parking lot.

For most cars the noise level is dependent significantly from the rotational speed of the engine and may be defined according to a formula [18]:

$$L = 30\lg(n) + L_0 \quad , \tag{3}$$

where:
n – rotational speed of the engine (rotation/min), L_0 – constant [dB(A)].

That is why parking of lorries with the engines running causes the rapid rise of the noise intensity on the parking lot. Such a situation was observed in MOP Chechło where, because of the intensive car traffic on the parking lot itself and the big number of delivery vehicles, the mean value of noise intensity 50 m away from the road behind the sound absorbing screen was higher by 4 dB(A) than in a point 50 m from the road, but without the screen.

The fourth points of measurement were located in case of MOP Proboszczowice 75 m from the road and MOP Wirek 100m from the road, and were both located in the places where you can eat your meal. In case of MOP Wirek the lowest results were obtained and the mean value of the all measurements for that point was 46 dB(A). This low result is caused by the fact that the places where you can eat are 25 m away from the parking lot itself and you can get there only on foot, using a

sidewalk. In case of MOP Proboszczowice the results of the measurements reached about 56 dB(A). The delivery vehicles and passenger vehicles moving less than 10m from that place of rest had major impact on those results.

6. CONCLUSION

Each driver, especially professional driver is obliged to rest during the journey. To do this you can use the specially prepared places called rest and service areas - MOPs. In those places certain elements shall be provided, which are parking lots, toilets, benches and acoustic climate that would enable a full rest. In the above paper the last element mentioned was discussed in detail and it was acoustic climate. It was assumed that on each parking lot the level of noise should be equal to the norms for the recreational areas and that is below 55 dB(A). The conducted research proved that only in two out of four places the noise level matches the norm [14]. The lack of sufficient protection against noise in the form of sound absorbing screens on the parking lots next to the motorway causes the inability to rest fully due to the noise. The achieved results showed, that in MOP Proboszczowice and MOP Chechło the rest is hampered by noise. The noise level in MOP Proboszczowice on its whole length exceeds the norm of 55 dB(A). In MOP Chechło, in the areas where the acoustic screen does not protect the parking lot, the level of noise is also too high.

Another problem is the noise coming from the vehicles moving on the parking lot itself. The maximum instantaneous noise intensity was observed when delivery vehicles started the engines after a period of rest or when the refrigerator lorries switched on their devices. Another important factor was starting the engines and heating them up in case of delivery vehicles. In such case the noise intensity increase next to such vehicle was up to 5-6 dB(A), and the resting possibility for other drivers was hampered. It should be noted that, on each researched parking lots, the area for the delivery vehicles was neighbouring the area for passenger vehicles. In such conditions, a short 15-minute stopover does not always enable the driver to "catch his breath" before the journey continues. And in case of an 8-hour rest period, obligatory by law for the professional drivers, in too much noise may cause the lack of sufficient rest period. It may lead to a hasty decision to continue the journey earlier or frustration while driving, what may further be a threat for the driver himself and for the other users of the road.

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