Noise Properties of Reconstructed Motorway D1 Measured by CPX Open Trailer and Stability of Measured Data in Time and Distance

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Summary

The prolonged effects of road noise from the tyre/road interaction annoys people living in neighbouring residential areas and has also negative impact on the natural ecosystems long distances from the road. In order to follow EU Directive 2002/49/EC Czech government needs to monitor noise from the main road network. We measure noise pollution of selected road segments in the Czech Republic to monitor the changes in the properties of road surfaces. In addition, there is a need to persuade the national authorities that using an open CPX trailer (which is constructed and tested by our company according to ISO 11819-2) is the right measurement device which is able to bring good results from road pavement noise measurements. This article deals with the results of the tyre/road noise pollution measured on old and newly laid road pavements on the main motorway D1 Prague-Brno-Ostrava. Another aim of the measurements by the open CPX trailer is to prove that this device is able to bring useful results which can be used by the national authorities to make right decisions for future (re)construction of the Czech road network, which should be comfortable for drivers, residents and the natural environment as well. The measurement is a part of systematic monitoring of the road network and the results will be used for government authorities to make better decisions.

CPX, tyre, road, noise

1. Introduction

Noise is one of a number of stress factors in the living environment of people and has also a negative effect on fauna [1]. Scientific studies confirm that long-term noise exposure to humans is not only stressful, but the noise stress also causes health problems. Since transport policies are among the priority national policies, it is necessary to find acceptable solutions for constructions of new urban road bypasses, which reduce noise in urban areas but also increase noise in rural areas. The number of hybrid and electric vehicles is currently growing, which can reduce noise from traffic, but this reduction is only applicable up to 50 km/h. Electric and hybrid vehicles lose their function for noise reduction under higher speeds, when the dominant factor is noise from tyre/road interface. Therefore, it is necessary to choose the right measures that lead to the reduction of noise impact on the environment. In the Czech Republic, the systematic measurement of road pavement noise with the CPX method only began 3 years ago [2]. This method was selected for its usability for measuring noise over a long distance in real traffic. Our aim is to monitor changes in noise on the selected network of roads in real traffic in the Czech Republic. This study focuses on trends in noise properties of two types or road pavements – cement concrete (CC) and stone mastic asphalt 11S (SMA11S). The aim is to compare the trends in noise properties of road pavements used in the main artery. Neither there are comparable measurements of noise in the interface tyre/road in the Czech Republic, nor there is a database of road pavement noise properties. The measurements have only been made since 2012 and are to continue within the R&D project in at least next 3 years in order to determine annual changes in noise properties of the selected and newly constructed road pavements. Road pavements from exposed aggregate concrete, which are to be newly evaluated in terms of noise, are currently being laid on the motorway D1. Based on these findings, corresponding measures will be taken for the installation of road pavements on the new road infrastructure, and suitable anti-noise measures will be planned at sites with potential occurrence of over-limit noise values.

2. Material and method

2.1. Motorway D1 sites description:

Motorway D1 is the main road in the Czech Republic connecting the three biggest urban agglomerations. It connects the northeast part of the Czech Republic and the city of Ostrava with the agglomeration of Brno in the southern part of the country and then it runs west to the capital city of Prague. The general reconstruction of the motorway between Prague and Brno, which will be evaluated in the following years, is currently in progress. Therefore, the D1 motorway segment from the town of Vyškov past Mořice, Kojetín, Kroměříž with the interruption Říkovice-Lipník nad Bečvou (the motorway is still unfinished in this segment) was selected for the monitoring of changes in noise of the road pavement. Therefore, the measurements continue with a D1 motorway segment from Lipník nad Bečvou up to the town of Hladké Životice.

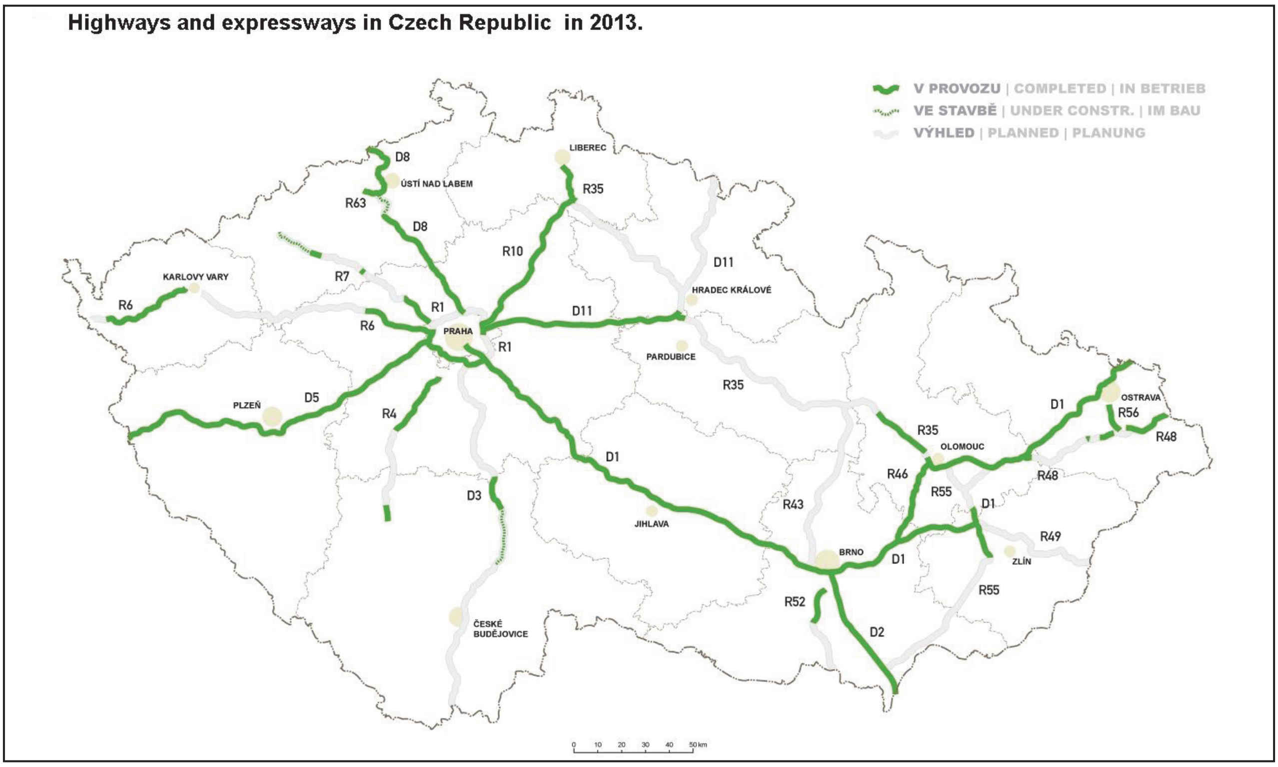

Fig.1 General road map of main motorways in the Czech Republic (www.ceskedalnice.cz).

The importance of the selected D1 motorway segment lies in its continuous construction, which allows to measure road segments with pavements of different ages within a single road. Each of the measured segments contains two types of pavements: cement concrete treated by burlap and stone mastic asphalt (SMA) 11S, which is used on bridges on the segments we measured, and on the measured segment No. 1. A single segment thus always contain an evaluated part with cement concrete and stone mastic asphalt 11 S. This ensures that both road pavement types have the same AADT within a single road segment. All the measured segments are shown in maps Figure 2a), Figure 2b).

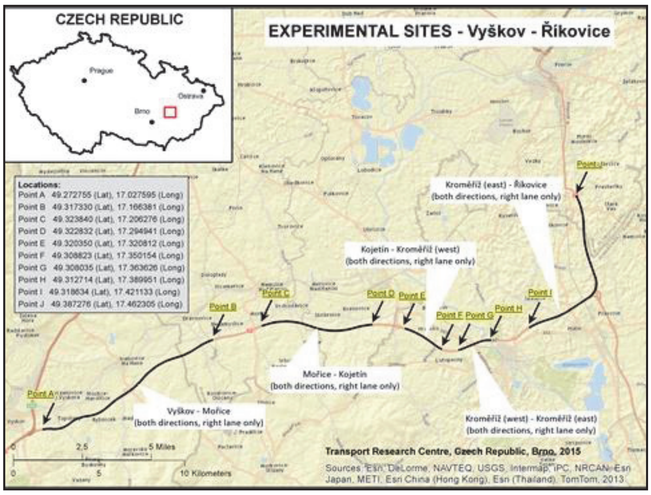

Figure 2a) Map of measured segments from Vyškov-Mořice to Kroměříž-Říkovice

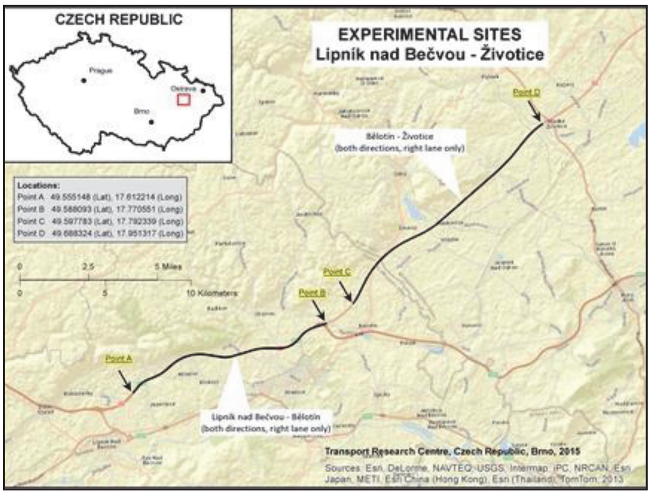

Figure 2b) Map of measured segments from Lipník nad Bečvou to Hladké Životice

The individual monitored segments were constructed in 2005, 2008, 2010 and 2011. The noise measurements were performed in the slow lane. Individual road segments differed with the model value of annual average daily traffic (AADT), as shown in Table I.

Table I. Annual average daily traffic

Date of measured segment construction	*AADT 2012 (based on traffic count in 2010)*	*Difference 2012/2013*	*AADT 2013 (based on traffic count in 2010)*	*Difference 2013/2014*	*AADT 2014 (based on traffic count in 2010)*
2005	8859	86	8945	172	9117
2005	8571	83	8654	166	8820
2007	8814	86	8899	171	9070
2008	15492	150	15643	301	15943
2009	23330	227	23556	453	24009
2010	16995	165	17160	330	17490
2011	13905	135	14040	270	14310

Daily traffic volumes are determined on the basis of the traffic count in 2010. In 2005-2009, AADT values were not calculated for the monitored road segments, since the given road segments were built after those dates.

2.2. Close proximity method equipment:

Close proximity method based on ISO 11819-2 Acoustics - Method for measuring the influence of road surfaces on traffic noise - Part 2: Close-proximity method [3], [4] was used for the measurements of road pavement noise. The principle of the method is measuring noise created at the point where tyre touches the road pavement. For the measurement of noise we produced an open CPX trailer, which is all made from round profile pipes, which reduce potential reflection of sound waves from the structure itself. When put into operation, the instrument was tested in accordance with standard ISO 11 819-2, which requires minimum differentiation of the background noise from bias at least 8 dB. These values, required by the standard, were met by a generous margin (article prepared for publication). Standard Reference Test Tyres (SRTT) P225/60R16 97S are mounted at both sides on the trailer structure. Five measuring prepolarized microphones for the free field in the accuracy class 1 are installed close to the right test tyre, i.e. farther from the central reserve of the road. They are connected by cables, led through a central protection plastic pipe, which are connected to individual parametric inputs of the module 3050-B-060, and the individual settings of the measuring channels can be controlled from the measuring laptop. A GPS is mounted on the measuring trailer – for the localization and to make the measuring test faster. The GPS is connected with a module CAN bus through LAN adapter to the controlling SW. Furthermore, a contactless infrared temperature sensor CALEX - PC21MT-0 is used, stating current temperature of the road surface. A cruise control of the towing vehicle is used in order to guarantee a stable speed. The measuring trailer is connected to the towing vehicle as shown in Figure 3. The measured data are processed by software PULSE LabShop from Brüel & Kjær. The raw signal is recorded by the software and archived for further processing and checking. The measurement output is the equivalent acoustic pressure level Lcpx from the measured section and its third-octave frequency spectrum. The signal is consequently processed with the use of a weighing filter A.

Figure 3 Czech open CPX measuring device

3. Results

The graph in Figure 4 shows that the noise level of the road pavement SMA 11 S, newly laid in 2011, grew between the first and third year after construction by approximately 1.0-1.5 dB(A) with the annual increase by 0.7 dB(A) between the first and second year, and by 0.6 dB(A) between the second and third year. Regarding the cement concrete pavement in the same time period, the increase in noise level was lower by nearly a half, i.e. 0.3 dB (A) between the first and second year and 0.3 dB (A) between the second and third year, i.e. the noise grew by the total of 0.6 dB (A) in the time period between the first and the third year, see Figure. 4.

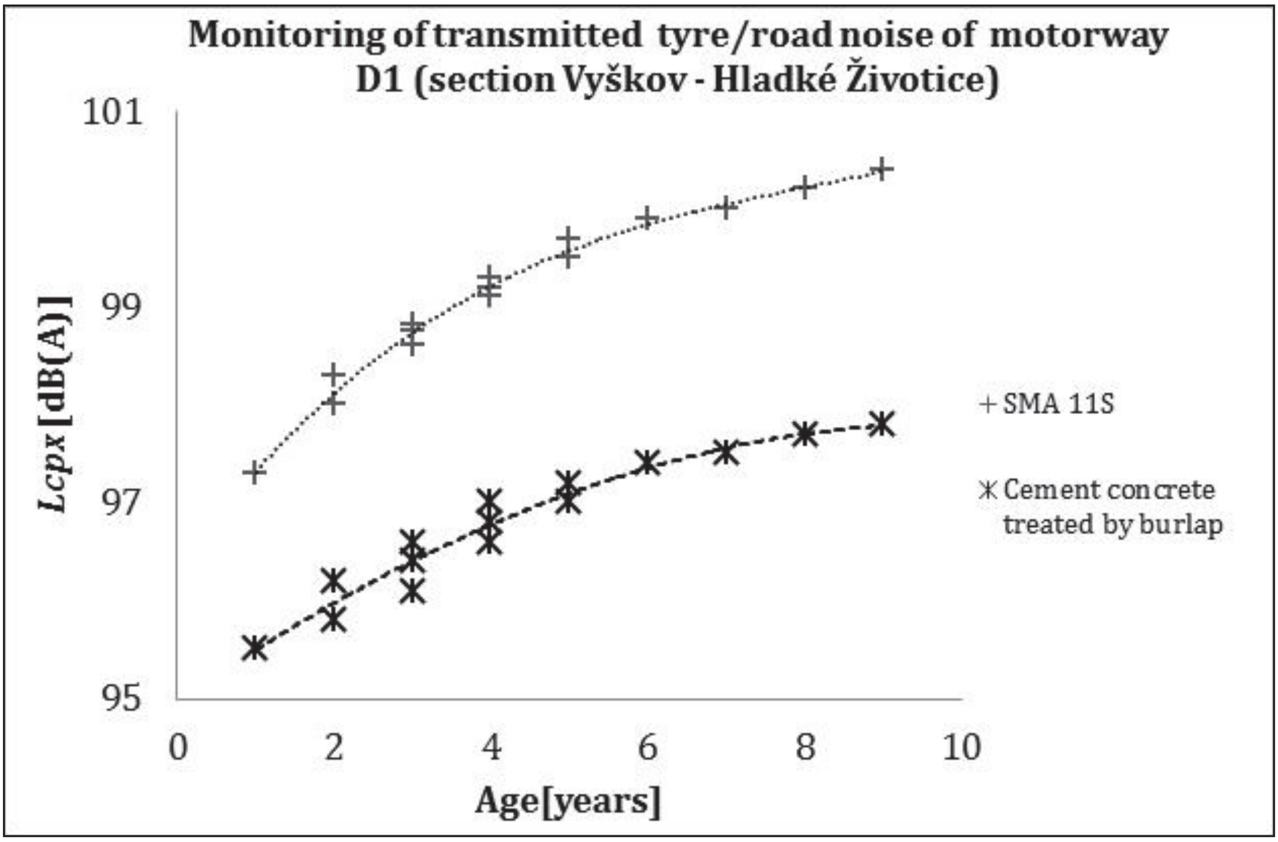

Figure 4 Comparison of year-on-year development of noise properties within 9 years of use of road pavements SMA 11 S and cement concrete treated by burlap.

The year-on-year comparison of other years shows an obvious trend in noise increase of both types of surfaces. The surface SMA 11S shows a year-on-year noise increase by 0.4 – 0.5 dB(A), while cement concrete with surface treated by burlap only shows a half of year-on-year noise increase, i.e. in the range of 0.2 – 0.3 dB(A). AADT can also play a certain role (there is twice or even three times more traffic on some road segments), as shown by the values from the model data based on the national traffic census in 2010. The concerned measured road segments were laid in 2008, 2010 and 2011. Another measured road segment Bělotín - Hladké Životice (built in 2009) had three times higher AADT, which ranged between 23 300 - 24 009 vehicles a day in 2012 – 2014. The noise of the road pavement can grow faster in comparison with road segments with less traffic. The available road pavement noise data only cover the time period of 2012 - 2014. A certain drawback for more accurate conclusions is the current lack of AADT data for the measured segments from 2005-2009 and the lack of measured noise emission data over time. The noise values show that the pavement SMA 11S loses its initial ability to absorb noise twice faster (faster growth in noise is particularly obvious during the first four years). However, the trend is also obvious in the long-term time horizon (the noise values of 7-year, 8-year and 8-year pavements exceeded 100 dB). Cement concrete treated by burlap also shows reduced noise absorption ability, but the growth in noise is nearly twice lower in comparison with SMA.

Comparing the time degradation of noise absorption abilities of pavements with the development of anti-skid properties of both monitored pavement types, we can see a similar trend in the life span of both pavement types as shown in the Methodology of the Ministry of Transport – Measurements of Road Surface Properties [5]. The comparison of results with different authors is rather difficult due to the variety of road pavement types on measured road segments or the use of different measuring methods in the works of other authors [6], [7], [8], [9]. We were unable to find a study comparable in all measured parameters, i.e. year-on-year comparison of noise properties of given road pavement types with the same age and road pavement type measured by CPX method on SRTT tyres). Another issue is the impact of traffic on the measured road segments, which is twice or even three times higher on some segments, which is a factor causing wear out and thus a noise level of the surface. Based on the obtained results, the surface of SMA 11 S at the end of its life span showed higher degradation of noise absorption properties from its seventh year of usage onwards, when the noise level exceeded 100 dB(A), while the values of noise for cement concrete between the 7th and 9th year of usage range between 97.5 and 98.0 dB(A). Regarding the total sum of year-on-year changes (for 9 years), the noise absorption properties of SMA 11S deteriorated by 3.1 dB(A) and of cement concrete only by 1.6 dB (A). In the following years, another road pavement type, exposed aggregate cement concrete (EAAC), will be measured and the results of noise absorption measurements will be compared with the original cement concrete as well as with the changes in this type of surface, which is already used on roads in Austria [9].

4. Conclusions

The monitored pavements of SMA 11S and cement concrete treated by burlap showed that the noise values of the monitored pavements increased during the use of individual pavements due to degradation. The increase of the noise emission was nearly twice higher for SMA 11 S than for cement concrete treated by burlap, where the degradation of surface was slower. These road segments, as well as newly constructed parts on D1 motorway, where the exposed aggregate cement concrete will be laid, will be further monitored in terms of year-on-year changes in noise levels. The authors believe that the results measured by the open CPX measuring device will be used in practice by road authorities in the Czech Republic as materials for further planning of new road pavement constructions on motorway D1 and other roads in the Czech Republic.

Acknowledgement

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