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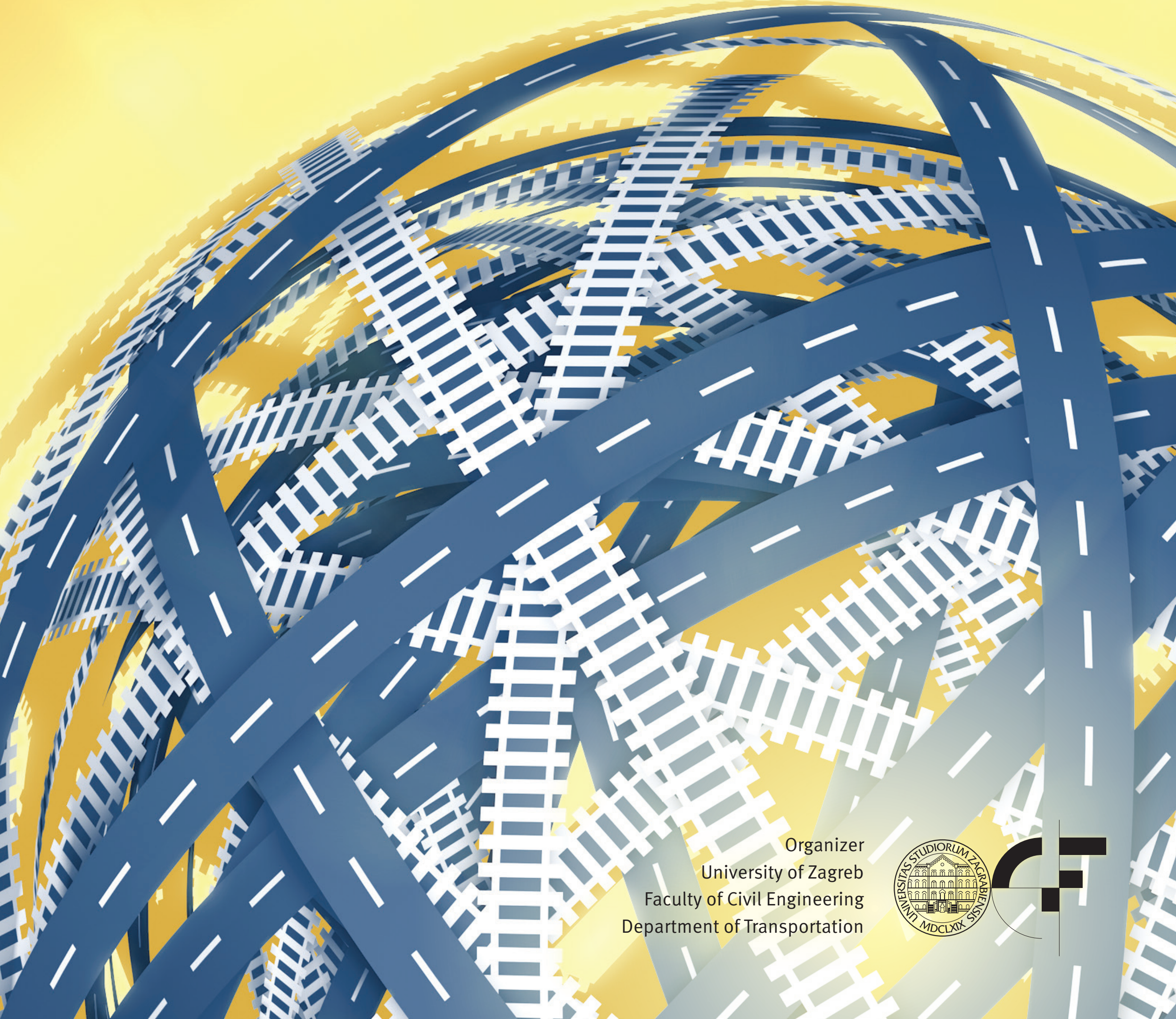
23–25 May 2016, Šibenik, Croatia

Road and Rail Infrastructure IV

Stjepan Lakušić – EDITOR



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Road and Rail Infrastructure IV

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IN-SITU ASSESSMENT OF LOW NOISE ASPHALT PAVEMENTS ACOUSTICAL PERFORMANCE

Audrius Vaitkus, Viktoras Vorobjovas, Tadas Andriejauskas
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Abstract

Paper presents Lithuanian low noise test road that consists of 9 different short sections constructed from recently developed low noise asphalt pavements for regional climate conditions (SMA5 TM, SMA 8 TM, TMOA 5), traditional asphalt mixtures (AC 11 VS, AC 8 PAS-H, SMA 8 S, SMA 11 S), porous asphalt mixture (PA 8) and special low noise asphalt product. After 6 months of exploitation, wide spectrum of measurements and tests were performed in-situ. Paper presents analysis and comparison of research results, collected after noise level measurements with Close Proximity (CPX) method. Despite the fact, that in every short section of test road both lanes were constructed of the same asphalt mixture, large noise level differences between the lanes were identified and could be associated with the installation heterogeneity. Analysis include CPX noise level values comparison for different low noise asphalt pavements with relation to surface texture pattern and properties, driving speed and vehicle/tire types.

Keywords: Low noise pavements; test road; CPX measurements

1 Introduction

In a recent decade, road transport noise problem and its negative impacts received huge attention from Road Authorities, City Municipalities and various organisations whose responsibilities more or less related with the noise abatement and mitigation. At the same time, increased attention fostered development and implementation of efficient road transport noise management solutions.
According to the EC calculations [1] annual EU socio-economic costs because of traffic noise are approximately 40 billion EUR and expected to increase 50 % by the 2050. It should be noted that these costs are mainly caused by the traffic of light and heavy duty vehicles. Negative impacts of road transport noise can be classified to three main groups [2, 3]: human related (sleep disturbance, annoyance, psychological stress, cardiovascular, mental state, hearing system, central nervous system, autonomous nervous system, learning/understanding/communication performance, work efficiency and other disorders or diseases); animal related (reproduction and migration of some animal species); economic related (real estate depreciation).
Vehicle generated noise can be divided into three noise sources (propulsion noise, tyre/road noise and aerodynamic noise) which are mostly dependent on the driving speed [4, 5]. At low speeds (up to 40 km/h) propulsion noise is a main contributor to overall vehicle noise while at the higher speeds (40-100 km/h) tyre and road interaction mechanisms contributes to approximately 90% of emitted acoustics energy and becomes dominant component in the vehicle noise context. At very high speeds, aerodynamic noise starts to be the main vehicle noise source.

Tyre/road noise is a dominant vehicle noise source in the cities or urban areas where negative noise impact is the highest. One of the most effective ways to reduce tyre/road noise is application of low noise asphalt mixtures [4-6]. Use of low noise pavement can be also substantiated by the fact that traditional noise mitigation solutions like noise walls/barriers, despite their good efficiency in noise reduction, are quite expensive to build and to maintain as well as the application in cities is not always possible due to various restrictions.
Low noise pavements has been used for a long time in Europe and huge efforts were made for the low noise asphalt mixtures development [4, 7, 8]. However, most of the experience is related with the porous asphalt mixtures which application in colder climate conditions is limited [9]. Therefore, the transferability of effective low noise pavement solutions from warm climate countries are questionable and not always efficient. For such reason, large research programme were initiated in Lithuania, with the main aim to develop low noise asphalt mixtures for regional climate conditions (approx. 60-80 annual frost-thaw cycles).
Development was started in the Road Research Institute (RRI) of Vilnius Gediminas Technical University (VGTU). Conventional SMA and AC mixtures were modified for noise reduction by optimising their surface texture (smaller max. aggregate size, concave texture) for tyre vibrations reduction and increasing air void content for better sound absorption [10]. Optimised low noise asphalt mixtures SMA 5 TM, SMA 8 TM and TMOA 5 were tested and compared with conventional asphalt mixtures SMA 8 S, SMA 11 S, AC 8 VS, AC 11 VS, AC 8 PAS-H, porous asphalt PA 8 and special patented noise reduction pavement [11]. Laboratory testing included determination of physical and mechanical properties, noise reduction properties (texture, sound absorption), durability properties and resistance to climate conditions. Positive and promising laboratory results led to the second research stage – pilot implementation and further low noise asphalt mixture assessment under real traffic and climate conditions.

2 Test road of low noise pavements

As it was indicated above, according to the laboratory testing results and estimations that developed low noise asphalt mixtures for regional climate conditions should reduce noise by 2-4 dBA, it was decided to construct test sections and perform further research of low noise pavements. The aim is to increase the level of living quality of population by testing low noise pavements in real traffic and environmental conditions, evaluating noise reduction characteristics dependent on asphalt mixture type and duration and level of exploitation.
Test Road of Low Noise Pavements was constructed in September, 2015 on a highway of national significance. Highway A2 Vilnius-Panevėžys is a two lane dual carriageway road which connects two large cities – Vilnius and Panevėžys. Test Road was constructed on a right side of the highway in the direction to Panevėžys at 56.07-57.57 km. Average annual daily traffic (AADT) in different parts of this highway varies from 7000 to 10000 vehicles per day. Speed limit is 110 km/h.
Test Road is 1.5 km in length and consists of 9 short sections where asphalt wearing layer was constructed using different asphalt mixtures. Those mixtures include 3 noise reducing asphalt mixtures (TMOA 5, SMA 5 TM, SMA 8 TM) developed by VGTU RRI for Lithuanian climate conditions, 1 porous asphalt mixture (PA 8), 1 special pavement and 4 traditional asphalt mixtures (SMA 8 S, SMA 11 S, AC 11 VS, AC 8 PAS-H). Main characteristics of the sections are presented in Table 1.
Such scope in variation of different pavement types is needed to perform long-term comparative monitoring of road surface characteristics, noise reduction properties, functional properties, resistance to climate conditions and durability between the different pavement types under real traffic and climate conditions.

Table 1 Main characteristics of the Test Road of Low Noise Pavements

Pavement type	Layer thickness [cm]	Section length [m]	Pavement width [m]
PA 8	4.0	100	11,25-11,60
SMA 8 S	3.0	175	8,55-8,75
SMA 11 S	3.0	175	8,55-8,75
AC 11 VS	3.0	175	8,55-8,75
AC 8 PAS-H	2.5	175	8,55-8,75
TMOA 5	2.5	175	8,55-8,75
SMA 8 TM	2.5	175	11,25-11,60
SMA 5 TM	2.5	175	11,25-11,60
Special pavement	2.5	175	11,25-11,60

3 Monitoring and testing of low noise pavements

3.1 Full measurements plan

Large set of periodic measurements in the Test Road of Low Noise Pavements are planned for the next 3 years: noise level measurements of passing vehicles using Statistical Pass-By (SPB) method (EN ISO 11819-1); tyre/road noise measurements using Close-ProXimity (CPX) method (ISO/DIS 11819-2); mean texture depth (MTD) measurements using volumetric patch method (EN 13036-1); mean profile depth (MPD) measurements using laser texture measurement devices, including measurements of RMS and skewness parameters; sound absorption measurements in impedance tube using standing wave ratio (EN ISO 10534-1); air void content and layer thickness measurements in laboratory (from the drilled cores); visual assessment. Measurements are performed annually: twice in spring (when average daily temperature is higher than 5oC and when average daily temperature is 10-15°C) and once in autumn (before the winter season). Before noise measurements, every section of the Test Road are being visually inspected to evaluate road pavement condition, identify pavement deterioration and all distresses.

3.2 CPX noise level measurements

Tyre/road noise measurements in Test Road are performed using CPX method (ISO/DIS 11819-2). This method is based on test tyre rolling on the road or the test track surface with measuring microphones located close to the tyre surface.

Figure 1 Fragment from CPX noise level measurements

Measurements are performed using CPX trailer (Figure 1) towed by a light vehicle. Trailer has two measurement wheels which are covered with the trailer case to isolate microphones from

unwanted outside sound sources, wind or traffic influence. Parallel to the CPX measurements, driving speed, road section length, GPS coordinates, air and road surface temperature are measured too.
CPX noise level measurements on both traffic lanes are performed at four different speeds: 40, 50, 80 and 100 km/h. Such measurement speeds are selected with a purpose to accurately determine road surface influence on noise generation mechanisms depending on the driving speed.
Two sets of measurement tyres to represent passenger cars and heavy duty vehicles were used. For passenger car representation standard reference test tyres (SRTT) are used and for heavy duty vehicle representation – Avon Supervan AV4 tyres (AAV4).

4 Analysis of the results

CPX noise level measurements were performed 1 month after Test Road of Low Noise Pavements construction. Measurement results for all short sections on both lanes at different driving speeds and with different sets of tyres are shown on Figure 2, 3, 4 and 5.
When comparing measurement results on 1st and on 2nd traffic lanes, it was found that differences between CPX noise level values of the same asphalt mixtures were not very high (less than 1.5 dBA) for almost all of the short sections. However, 1.5 dBA and higher differences between the traffic lanes were determined for the low noise asphalt mixtures PA 8, SMA 5 TM and SMA 8 TM. At very high speeds, differences were determined up to 2.5 dBA. Such big differences might be explained as a construction error (heterogeneity) – during wearing layer construction, mixtures on both lanes were compacted differently. Differences between the level of compaction on 1st and 2nd traffic lanes were 3-4%. As the noise reduction properties are strongly related with the air void content, over compaction of the mixtures with designed higher air void content, led to the large deviations in CPX noise levels.
Analysis of the CPX noise levels depending on the speed showed, that optimised low noise asphalt mixtures SMA 8 TM, SMA 5 TM and TMOA 5 and porous asphalt PA 8 have lowest CPX noise levels at all speeds and for both tyres (SRTT and AAV4). The highest noise levels were determined for SMA 11 S, SMA 8 S, AC 11 VS and special pavement.
Difference between the asphalt mixtures with highest and lowest CPX noise levels varies from 3 to 6 dBA, depending on the driving speed – higher the speed, higher the difference between the pavements.
Typically noise levels caused by the heavy duty vehicles are higher than passenger vehicles. Specific analysis of noise levels with both SRTT and AAV4 tyres were performed to investigate which asphalt mixtures are better for heavy duty vehicles noise reduction and which for passenger vehicles. Such analysis also was important to check if optimisation of SMA 5 TM, SMA 8 TM and TMOA 5 mixtures were done right – SMA 5 TM and TMOA 5 mixtures were designed with max. aggregate size of 5 mm (specifically for passenger vehicles noise reduction) and SMA 8 TM were designed with max aggregate size of 8 mm (for heavy duty vehicles noise reduction). Measured CPX noise levels confirmed the hypothesis – SMA 5 TM and TMOA 5 noise levels for SMA 5 TM and TMOA 5 with SRTT tyres approx. 2 dBA are lower than noise levels with AAV4 tyres.
From a surface texture point of view, according to the measured CPX noise levels, it can be stated that noise reduction for SMA 8 TM, SMA 5 TM and TMOA 5 mixtures is based not only on better sound absorption (higher air void content) as it is for porous asphalt PA 8, but also reduction of tyre vibrations (concave and smooth texture).

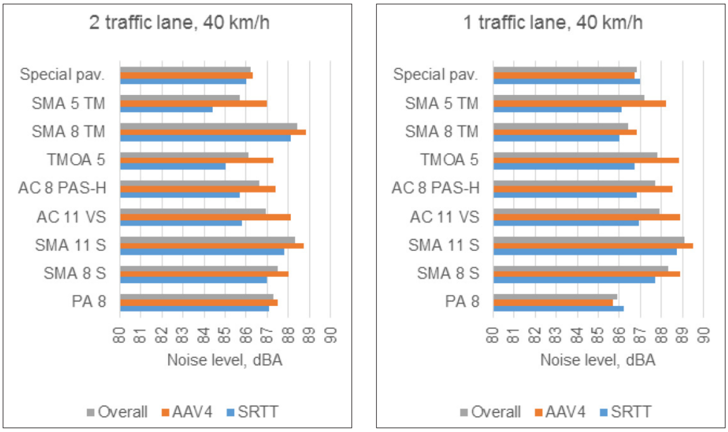

Figure 2 CPX noise level on both lanes at 40 km/h speed

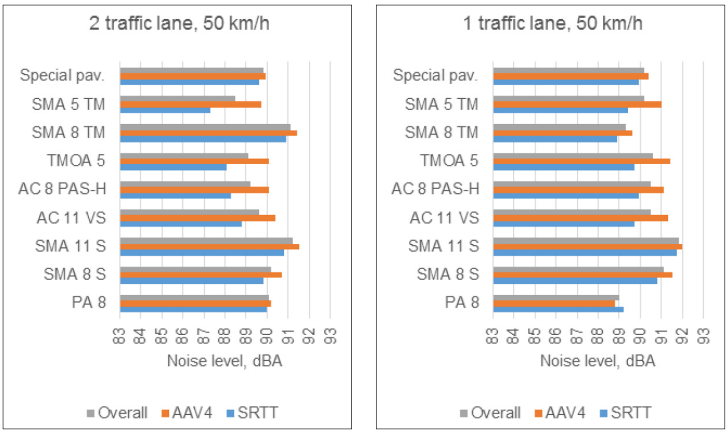

Figure 3 CPX noise level on both lanes at 50 km/h speed

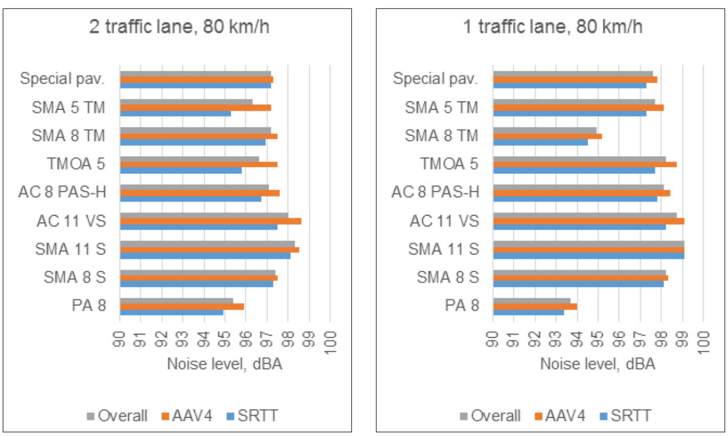

Figure 4 CPX noise level on both lanes at 80 km/h speed

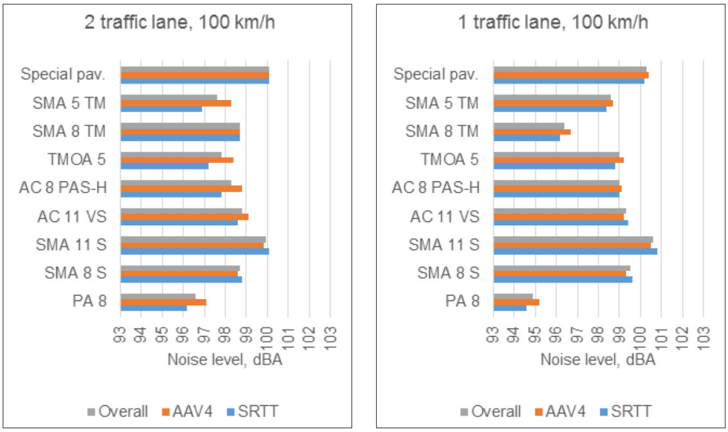

Figure 5 CPX noise level on both lanes at 100 km/h speed

5 Conclusions

Increasing road transport noise problem requires effective and efficient noise abatement and mitigation solutions. Low noise pavements is a very good solution for urban areas or cities, where driving speed is not so high and the dominant vehicle noise source is tyre and road interaction. Effective low noise pavement solutions such as porous asphalt are not very well suitable for colder climate countries due to large number of annual frost-thaw cycles. Therefore, thin layers with optimised surface texture and increased air void content seem to be a compromised solution for both noise reduction and sufficient durability.

Low noise SMA 5 TM, SMA 8 TM and TMOA 5 asphalt mixtures for severe climate conditions were developed in VGTU RRI and were constructed on operating road in Lithuania for further testing under real traffic and climate conditions.

CPX measurements showed that there are quite large differences between 1st and 2nd traffic lanes, in sections constructed of PA 8, SMA 8 TM and SMA 5 TM, differences at higher speeds are even 2.5 dBA. These deviations were mainly caused by the inhomogeneous asphalt layer compaction. This issue revealed the necessity to develop guidelines/requirements for low noise pavement construction.

Since the Test Road of Low Noise Pavements is newly built, the CPX noise level results are preliminary and cannot give accurate expectation of how developed low noise pavements will deteriorate in terms of noise reduction. This will be investigated and analysed after 3 years of periodic CPX, SPB, texture, acoustic absorption and other relevant measurements.

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