On the acoustic long-term performance of asphalt and concrete road surfaces on Austrian motorways

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Summary
In the frame of a national project financed by the Austrian national road administration (ASFINAG) from summer 2013 to summer 2014 the Austrian Institute of Technology (AIT) performed a study on the long-term performance of several road surfaces currently used on the Austrian motorway. The scope of this study was to measure different asphalt and cement concrete pavements according to the following regulations: the Austrian trailer method according to the directive RVS 11.06.64, the international pass-by method according to ISO 11819-1 (also called SPB-method) and the international trailer method according to ISO/DIS 11819-2 (also called CPX-method). The present paper shows the main results of the measurements performed, as well as the time series including also data from a previous study performed by the Technical University of Vienna between 2006 and 2012. The results of these two studies were combined in order to compile a significant data basis.

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1 Introduction

With growing traffic intensity, road network providers are challenged to keep noise abatement measures up with the increasing noise exposure along their routes. As the tyre noise emission limits introduced in the EU regulations 2009/661/EG [1] and 2009/1222/EG [2] could not reduce the noise emission at the source [3, 4], the main potential of noise abatement is found in noise barriers as well as low-noise road surfaces.

The further development of low-noise road surfaces is thereby challenged by the different properties a road surface has to exhibit. Safety-relevant aspects such as skid resistance, environmental factors as rolling resistance and noise emission are mainly influenced by the surface texture, and therefore – depending on the texture wavelength – interact. The project ROSANNE [5] is currently aiming at developing and harmonising measurement methods for these road properties

Next to this, advanced road surfaces such as porous road surfaces are extremely strained by heavy traffic. In addition to this, winter maintenance, especially in alpine and northern countries, poses an added challenge to the pavement. The long-time performance of the acoustical properties of road surfaces under harsh conditions is therefore an important property for pavements used in the high-level road network.

In the years 2005 to 2011, the Austrian Federal Ministry of Transport, Innovation and Technology and the Austrian highway road administration ASFINAG have commissioned an extensive study on the long-time performance of noise-reducing road surfaces. Along the A12 highway, eight different road surfaces were installed and monitored. Next to their acoustic behaviour, also the non-acoustic properties skid resistance, texture and draining behaviour were measured by the Technical University of Vienna and the AIT Austrian Institute of Technology. The results of this study are publicized in [6]. In continuation of this research, the AIT was commissioned by the ASFINAG in 2013 to further perform acoustical measurements on these test tracks as well as to supplement the results with exposed aggregate cement concrete pavements. In this paper, the results of these investigations are presented.

2 Measurement methods

In total, three different measurement methods were used to determine the acoustic properties of the road surfaces. Due to budgetary limitations, not all methods could be conducted on all pavements.

In Austria, sound propagation calculations are regulated by RVS 04.02.11 ("Richtlinien und Vorschriften für das Straßenwesen", guidelines and regulations for road engineering [7]). The emission properties are based on statistical or controlled pass-by measurements as described in ISO 11819-1 [8]. The speed vs. sound emission level regression analysis is then used to provide a speed-dependent sound emission function per vehicle pass-by.

Next to this, to enable the monitoring of the road surface condition on a network level, a trailer method similar to the CPX method ([9]) is described in RVS 11.06.64 [10]. This method is mainly used for acceptance testing of newly constructed road surfaces and results in the so-called LMA value. Its main differences to the CPX method are the usage of a PIARC test tyre as well as different microphone positions located behind and on the side of the test tyre. The measurements were performed at speeds of 70 and 100 km/h.

Finally, the CPX method was used for the investigations. As the currently performed measurements were aimed to be comparable to the preceding measurements, instead of the ASTM SRTT, the in 2005 stipulated AVON ZV1 test tyre was used. Also these measurements were performed at speeds of 70 and 100 km/h.

2.1 Test sites

The different road surfaces as well as the measurement methods used can be found in Table I. The first seven pavements were installed in the scope of [6], the exposed-aggregated cement concrete road surfaces were added to the measurement campaign and supplemented with measurement data from previous projects.

As the asphalt road sections were installed at the same time adjacent to each other with an average length of 500 m, the traffic volume on these pavements is expected to be constant at approx. 3.900 heavy trucks per 24 h. In comparison to this, the EACC 8 section has a traffic volume of 2.100 heavy trucks / 24 h, the EACC 11 section of 1.200 heavy trucks / 24 h.

3 Results

3.1 SPB measurements

In Figure 1 and 2, the results of the SPB measurements at test section "Low-Noise SMA 8" respectively "EACC 8" are depicted. The three diagrams show the results for the vehicle categories passenger cars, light and heavy trucks. To illustrate the results of the regression analysis, the data points show the $L_{A,eq}$ of a single vehicle pass-by in 1 m distance, evaluated at 80, 100 and 130 km/h for passenger cars and light trucks (green, blue and red colours), and at 60 and 80 km/h for heavy trucks (green and blue colours). As abscissa, the pavement age at the time of the measurement is used.

From this, a regression analysis of sound emission vs. pavement age was calculated (solid lines).

Table I. List of the road surfaces and measurement methods

Road Surface Type	SPB (ISO 11819-1)	RVS 11.06.64	CPX (ISO/DIS 11819-2)
Low-Noise SMA 8	X	X	X
Low-Noise SMA 11	X	X	X
SMA 11		X	X
Low-Noise SMA 11 (PmB)		X	X
double-layer open porous asphalt (PmB)		X	X
double-layer open porous asphalt (rubber modified)		X	X
single-layer open porous asphalt 8		X	X
exposed-aggregate cement concrete 8	X	X	
exposed-aggregate cement concrete 11	X	X	

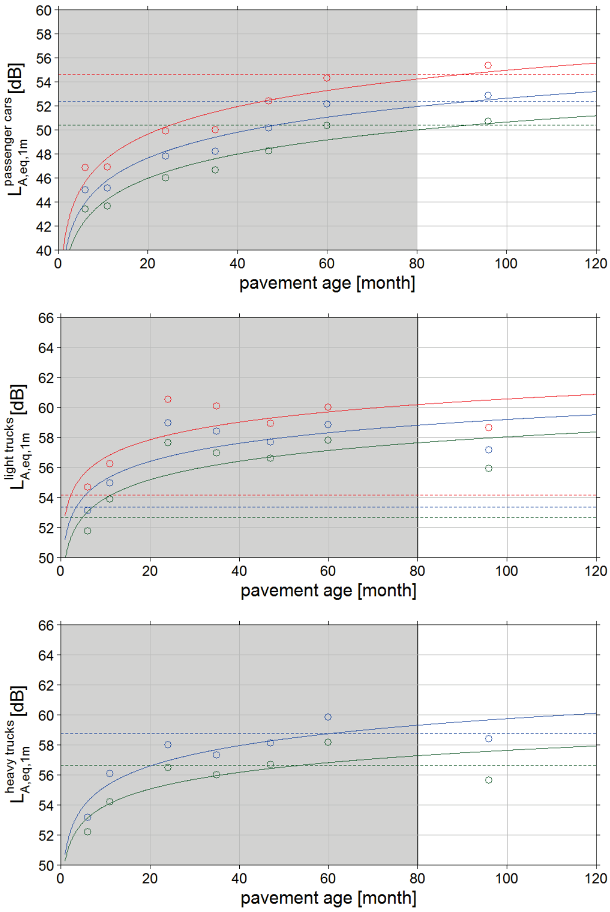

Figure 1. Results of the SPB measurements for the pavement “Low-Noise SMA 8”

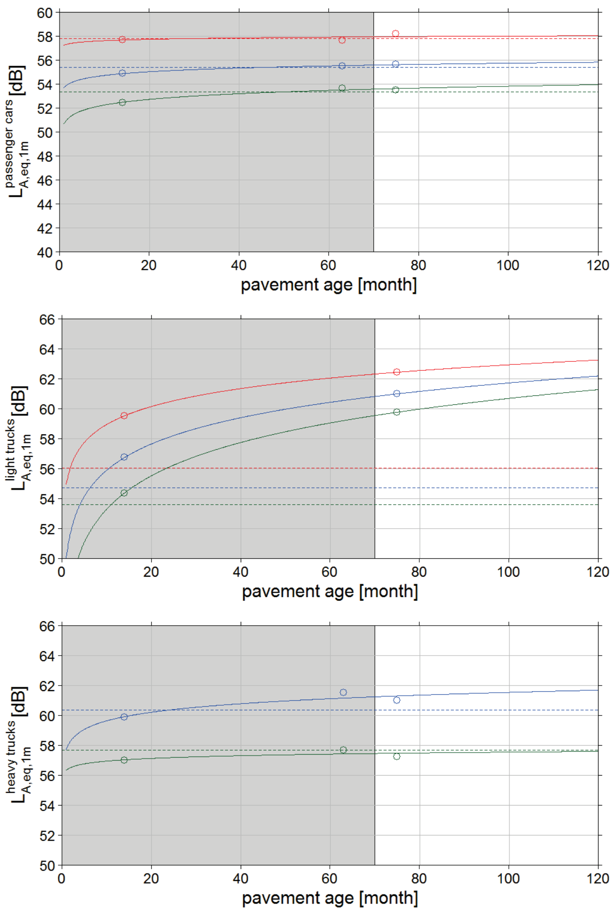

Figure 2 Results of the SPB measurements for the pavement “EACC 8”

As the degradation of the pavement and therefore its acoustic properties are expected to be non-linear, a logarithmic regression was chosen according to

$$L_{A,eq} = a + b \cdot \ln(t) \qquad (1)$$

One can clearly see that the logarithmic regression analysis provides a good approximation especially for passenger cars ($R^2 = 0.91$).

The grey backlighted area characterizes historic datasets, the dashed lines depict the values as currently mandated in RVS 04.02.11. Although the pavement is already nine years old, these values still prove to be valid parameters to describe the emissions of the road surface.

Problems occur mainly for the vehicle category of light trucks. One can see that the results of the SPB measurements deviate severely from the values used in RVS 04.02.11. This problem arises for all test sections; as the vehicle category definition includes a large variety of different light trucks, a consistent classification with the historic data cannot be ensured. Therefore the results for this category should be questioned.

The results of the SPB measurements for EACC surfaces (as an example, the test section of EACC 8 is depicted in Figure.2), show notably different long-time behaviour. For passenger cars as well as heavy trucks, $L_{A,eq}$ values are constant over time. Again, the category of light trucks has to be rendered moot.

For all road surfaces, the speed-dependent differences between the $L_{A,eq}$ were calculated over time and statistically analysed. It is interesting to note that for all pavements, no relevant alteration of the speed-dependence of the tyre/road noise could be found.

The coefficient *b* in the logarithmic regression analysis shows large differences between the asphalt and the EACC surfaces. For the asphalt test sections, values of *b* are in the range of 2.7 and 3.3, for the EACC pavements between -0.4 and 0.7 with negative values even indicating an improvement of the acoustic properties over time.

3.2 RVS 11.06.64 measurements

Results of the trailer measurements according to RVS 11.06.64 are in accord with the pass-by measurements. Figure 3 illustrates the "Low-Noise SMA 8" test site. Here, measurement speeds were chosen as 70 and 100 km/h. Also with this measurement method, a faster degradation at the beginning of the pavement lifetime can be found, as the coefficient of determination of a logarithmic regression analysis according to (1) with $R^2 > 0.91$ substantiates.

Figure 3 can be seen as representative for all asphalt surfaces; the coefficient *b* in the logarithmic regression analysis varies between 1.2 and 2.7.

Due to the lack of long-time datasets for EACC surfaces, no significant conclusions could be drawn from the existing measurements with the RVS 11.06.64 method.

3.3 CPX measurements

For comparison reasons with previous data, measurements according to ISO/DIS 11819-2 were conducted using the "old" tyre representing passenger cars of type Avon ZV1.

The results of the representative test track "Low-Noise SMA 8" are shown in Figure 4. The final measurements exhibit nearly the same values as the previous dataset, which indicates that the road surface has reached a constant state.
Also for the CPX measurements, not enough datasets exist to draw significant conclusions regarding the EACC pavements.

4 Discussion

As the acoustic properties of road surfaces change with time and degradation, the question of correct input values for noise propagation calculations near major transport routes arise. Depending on the road surface type, different ageing effects have to be accounted for. Knowledge of the long-time performance of the pavements is necessary to enable a thorough noise protection planning.

By the summary of measurement campaigns shortly outlined in this paper it could be shown that the degradation of the acoustic properties of the pavements is non-linear. Faster increases in noise emission of vehicle pass-byes at the beginning of the life-time of the pavements suggest the use of a simple logarithmic regression model to describe the ageing behaviour of the road surfaces. The slope of the ageing depends seemingly on the road surface, especially on the surface class.

A clear dispartment of the long-time performance of road surfaces could be determined between asphalt and exposed-aggregate cement concrete road surfaces. Although exhibiting higher emission parameters at the beginning of their lifetime, EACC surfaces seem to display a distinct lower acoustic degradation.

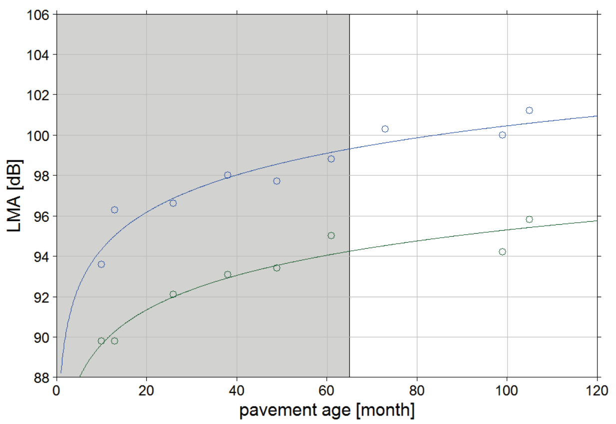

Figure 4. Results of the RVS 11.06.64 measurements for the pavement "Low-Noise SMA 8"

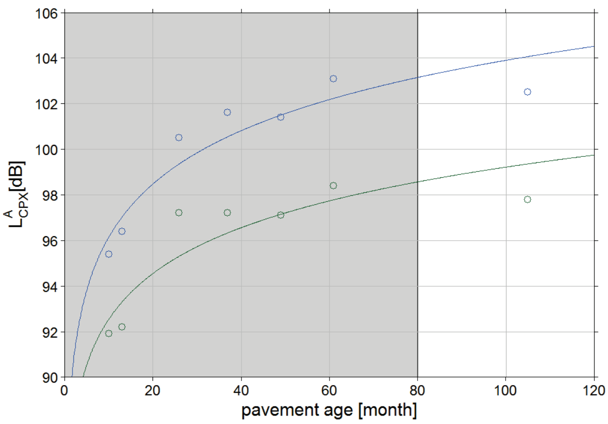

Figure 3. Results of the CPX measurements for the pavement "Low-Noise SMA 8"

Focusing on Austrian circumstances, the parameters used for propagation calculations prove to be valid also after years of heavy usage.

Generally, the question of embedding long-time performance indicators of the acoustic properties of road surfaces needs to be discussed. This also shows the need for a harmonised approach for the characterization methods for approval testing, monitoring and the determination of input values for noise propagation calculations on a European level as currently investigated in the project ROSANNE.

Acknowledgements

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