PARTIAL RESULTS ON THE WAY TO ESTABLISHING NOISE CLASSIFICATION LEVELS FOR ROAD SURFACES

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ABSTRACT

Several parameters are monitored on roadways as skid resistance, surface roughness, defects, and bearing capacity. These parameters have classification scales for evaluation, but not yet the noise level. The paper provides partial results of the research project of the Technology Agency of the Czech Republic CK02000121. Its aim is to determine a classification scale of road surfaces and to develop proposals for a possible noise assessment of surfaces. The paper presents the results of tire/road noise measurements (by CPX method) of real road surfaces in the Czech Republic. CPX method is the most used method for measuring road surface noise according to a survey conducted by CEN. From an acoustic point of view, road surfaces can be divided into 3 basic groups. These are conventional surfaces such as SMA, AC, or EACC, high-noise pavements such as cobblestones, and low-noise pavements such as BBTM or cement concrete treated by burlap drag method.

Keywords: *CPX method, surface noise, classification levels.*

1. INTRODUCTION

Noise pollution has a significant impact on the environment and human health. The major source of (constant) noise is traffic, especially road traffic. In towns, the maximum velocity of vehicles is usually 50 km/h and is frequently higher on the road through built-up areas. Lowering the speed limit from 50 km/h to 30 km/h is a current trend in European cities for many reasons (e.g., road safety [1, 2], and health benefits as noise lowering [2, 3]). Tire/road noise starts to dominate at speeds from 40 km/h for passenger cars with combustion engines. However, the European Green Deal prioritizes the uses and sales of electric vehicles, where tire/road noise is dominant at velocities from 20 km/h [4, 5]. The condition of the road surface will therefore become increasingly important.

Surface maintenance involves non-variable and variable parameters that are used to monitor the condition of the road network. The non-variable parameters do not change without construction intervention (cross slope of the road, composition of the road construction, etc.). Variable parameters are, on the other hand, changed by traffic loads, climatic influences or ageing of materials. Variable parameters include skid resistance, surface roughness, bearing capacity, defects, and noise. The first four parameters mentioned earlier have numerical classification scales that are used in pavement assessment, design, maintenance, or repair. Surface noise, however, has no classification scale.

The parameters skid resistance, surface roughness, bearing capacity, and defects are classified in tiers from one to five. Tier 1 is for new pavement after laying (parameters of the control test at construction takeover, the best condition), tier 2 is for the end of the warranty period, tier 3 is after the warranty period and in good condition (free of defects, potholes etc.), tier 4 is also after the warranty period but in degraded condition (potholes, cracks etc.) and the surface no longer meets the requirements for serviceability at tier 5 (bad condition, measure according to parameter is needed).

The paper presents partial results obtained within the framework of the project of the Technology Agency of the Czech Republic "CK02000121 Determination of values of classification levels for evaluation of road surface noise in the Czech Republic". The main aim of the project is to create the classification scale for road surfaces according to their noisiness.

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2. MEASUREMENTS AND METHODS

The CPX method according to standard 11819-2 [6] was used for the measurement. Method(ology) and instrumentation of measurement is described in detail in [7]. Open CPX trailer constructed by researchers of Transport Research Centre of the Czech Republic (CDV, see Fig. 1) was used for tire/road noise measurements. Open CPX trailer was designed in 2008 based on the foreign experiences, trailers and also CPX standard draft, which was developed by CEN/TC 227/WG 5 (CDV is the representative of the Czech Republic in this group). Until 2011, the trailer was verified and improved and since 2012 it has been used for measurements. The construction of the measuring device (trailer), the sound measuring apparatus and sensors (microphones) used have not been changed. Everything is regularly calibrated and verified (continuity with metrological standards). The only changes over the years have to do with the addition of a 6th microphone and regular hardness measurements.

Figure 1. Open CPX trailer designed by CDV.

3. SURFACE NOISE LEVELS

The following noise results of road surfaces are focused on the motorway network in the Czech Republic. The data originate from measurements of the motorway network connecting Prague with Ostrava belonging to the international transit network (D1, D11, D46). The exception is the cobblestone surface that was measured on 2nd class road. The noise results mentioned below were obtained for velocity 80 km/h. The measured sections were free of defects.

Cement concrete and asphalt with increased resistance to permanent deformation (letter S after the grain size number) are the most used surfaces because of the high bearing capacity of motorways. Low-noise surfaces (letters NH, Czech abbreviation for low-noise) are also used on some sections of motorways.

Each of the graphs (Fig. 2–6) below shows a comparison of the noise levels of two different surfaces laid in the same year. The surfaces were connected to each other, thus guaranteeing equal measurement conditions (temperature, traffic intensity, etc.). The Czech national reference noise value for surfaces measured by CPX method at 80 km/h is 98 dB(A).

The measurement results reported in the chapter below (3.1) include the parameter "years after laying". This indicates how long the surface has been laid, i.e. how old it is. For example, if the surface was laid in 2012 (year 0 after laying) and measured in 2020, then the surface is 8 years old, which also corresponds to 8 years after laying. A value of 0 corresponds to a measurement in the year of laying.

3.1 Tire/road noise results

Noise levels of two surfaces – stone mastic asphalt with the highest grain size of 11 mm with increased resistance to permanent deformation (SMA 11S) and exposed aggregate cement concrete with the highest grain size of 8 mm (EEAC 8) – can be seen in Fig. 2. The results are similar with maximum difference 0.3 dB(A). Surface noise levels are around the value 98.5 dB(A) one year after laying and rise by a further 1.5 dB(A) after another seven years. Both surfaces can be considered normal based on a comparison with the national reference value.

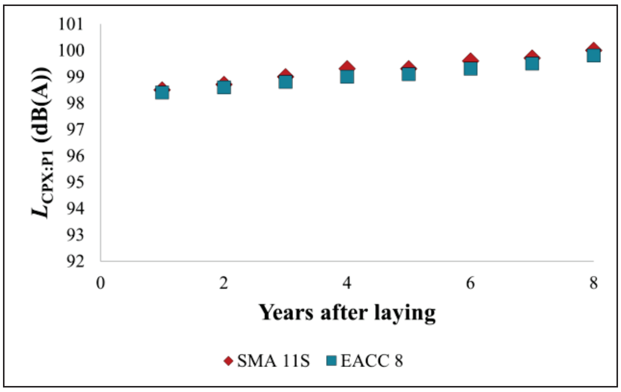

Figure 2. Comparison of the noise levels of SMA 11S and EACC 8 surfaces.

Cement concrete treated by burlap drag method (CC burlap drag) was used on motorways in the Czech Republic until 2012 because of insufficient skid resistance properties. However, the noise value eleven years after laying is lower than 98 dB(A) and surface can be considered low-noise. Comparison of low-noise CC burlap drag and SMA 11S surfaces is shown on Fig. 3.

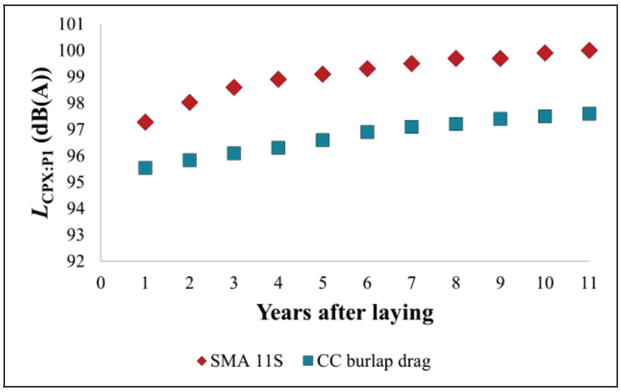

Figure 3. Comparison of the noise levels of SMA 11S and CC treated by burlap drag method surfaces.

Comparison of SMA 11S and low-noise stone mastic asphalt with the highest grain size of 8 mm (SMA 8 NH) is presented at Fig. 4. Noise value of SMA 8 NH four years after laying is 3.5 dB(A) lower than the SMA 11S value in the same year of service life. Noise level of low-noise surface is increasing faster every year than that of SMA 11S. The difference in noise level between the year of laying and the fourth year after laying the SMA 11S surface is 1.4 dB(A), while the SMA 8 NH surface is already 3.5 dB(A).

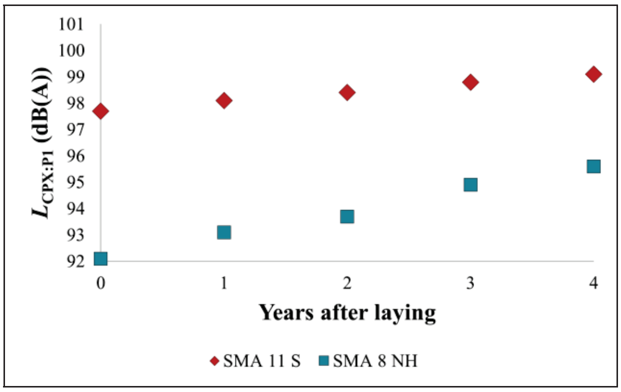

Figure 4. Comparison of the noise levels of SMA 11S and SMA 8 NH surfaces.

Comparison of pavement SMA 11S and low-noise asphalt concrete for very thin layers with the highest grain size of 8 mm (BBTM 8 NH) is shown in Fig. 5. The surfaces were laid earlier than in the previous case and therefore a longer timeline is available to compare the SMA 11S and low-noise surface. The noise difference in the year of laying is 3.1 dB(A) and eight years after laying the difference has reduced to 2.5 dB(A). Noise level of low-noise pavement eight years after laying has reached 98 dB(A). However, an unsatisfactory noise parameter is not a reason to replace an otherwise defect-free surface.

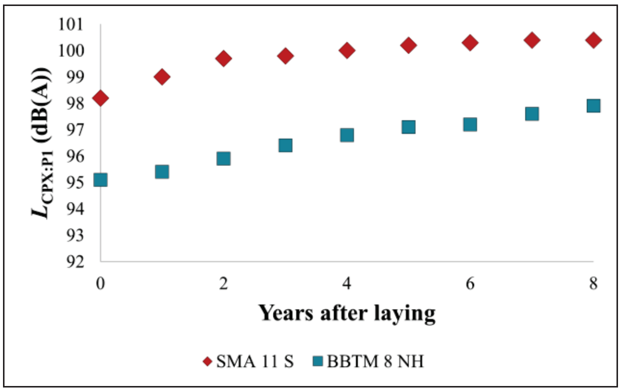

Figure 5. Comparison of the noise levels of SMA 11S and BBTM 8 NH surfaces.

Tire/road noise of BBTM 8 NH is lower than noise values of the asphalt concrete surface with the highest grain size of 11 mm with increased resistance to permanent deformation (AC 11S), as can be seen in Fig. 6. Noise level of low-noise pavement seven years after laying has not yet reached value 98 dB(A). This value was identical to the noise level of the AC 11S surface in the year of laying, namely around 97 dB(A).

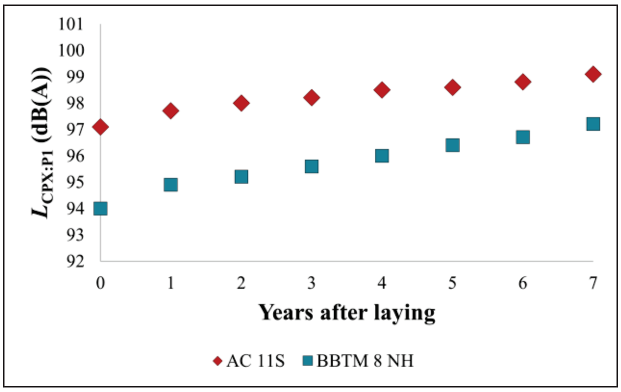

Figure 6. Comparison of the noise levels of AC 11S and BBTM 8 NH surfaces.

For the next surfaces, cobblestones, a graph was not produced because these surfaces have not been monitored for more than two years. Cobblestones are still preserved and preferred in some historic parts of the cities. However, they are also found outside the cities, but not on motorways or 1st class roads. Cobblestones were mostly laid thirty or more years ago. Measured noise levels at speeds of 80 km/h are higher than 104 dB(A).

3.2 Discussion

Two methods are mainly used to assess the noise performance of road surfaces – CPX according to 11819-2 and SPB according to 11819-1 [8]. The necessary input for the computational methods (modeling) is the data obtained by in-situ measurements by both methods, CPX and SPB. An example is the CNOSSOS-EU method [9]. But each method serves a slightly different purpose. The CPX method is the better method to use when comparing noise differences of surfaces only (measurement by the same tire mounted on the same trailer). With the SPB method, it is difficult to ensure that the same vehicle, the same speed, and the same tire are used to correctly compare different surfaces. In addition, the 11819-1 standard itself states: "*A practical way to check the homogeneity is to make a measurement with the CPX method (see ISO 11819-2) over the test section and note how typical the CPX level is on the intended SPB measurement spot.*"

Also, a questionnaire survey about methods of surface noise measurements was conducted by work group 5 within CEN TC 227 in 2021. Close-proximity (CPX) method is recommended method for road surface noise measuring in 9 out of 11 European countries participated on survey (the questionnaire survey is still in progress).

The most common surfaces are SMA 11 and AC 11 on roads in the Czech Republic. Noise values of these pavements tend to be similar under similar conditions. The EACC 8 surface also achieves similar noise levels. They can thus be called conventional surfaces. This statement is in accordance with the national reference values – noise level of reference surface corresponds with surfaces SMA 11 or AC 11 two years after laying, tire/road noise of reference surface reaches values of 98 dB(A) for 80 km/h and 90 dB(A) for 50 km/h [10]. Reference [10] is the Technical Quality Requirement approved by the Ministry of Transport which is implementing regulation of the national standard.

In contrast, the SMA 8 NH, BBTM 8 NH and CC burlap drag surfaces have noise levels lower than conventional surfaces mentioned above and the national reference value. In the Czech Republic, surface is considered low-noise if its noise level is at least 3 dB(A) lower than the national reference value immediately after laying. However, the uncertainty of noise measurement is 1 dB(A), so the difference between low-noise a reference pavement values must be at least 2 dB(A) [10].

Cobblestones represent an acoustically significant extreme. The noise level of cobblestones will be high above that of a conventional surface even after laying. The undoubted advantages of the cobblestone material include durability and resistance, but the main disadvantage, except for noise, is the danger of wet skidding. Despite the high noise level, cobblestone pavement is maintained in historic parts of towns based on the requirements of conservationists.

The currently valid scale in the Czech Republic applies only to low-noise surfaces. It is a two-point scale, i.e. it only gives information about whether the surface (does not) meets the low-noise surface definition [10]. It would be appropriate to maintain the uniform 1–5 classification format for noise with respect to the link to other variable parameters. So, the classification scale will thus have 5 tiers.

Based on consultations with experts and representatives of the Directorate of Roads and Motorways of the Czech Republic, the scale should have as simple a scheme as possible and should not have to be constantly supplemented, modified, and adjusted. It is expected that there will be two scales, one ("stricter") for low-noise surfaces (SMA 8 NH, BBTM 8 NH, CC burlap drag) and the other for conventional surfaces (AC, SMA, EACC). The maximum differences between the surface types within low-noise or conventional group are 2 dB(A), so this distribution is possible.

However, the project is still in progress and the scales are not yet finalized. Noise limits (tiers) of scales are a matter for further analysis.

4. CONCLUSION

The paper indicates that surface noise is one of the pavement variable parameters and should be monitored more in the future. The presented results show that road noise increases with age (year after laying).

From an acoustic point of view, road surfaces can be divided into 3 basic groups:

- conventional surfaces such as stone mastic asphalt, asphalt concrete or exposed aggregate cement concrete;
- high-noise pavements such as cobblestones;
- low-noise pavements such as asphalt concrete for very thin layers or cement concrete treated by burlap drag method.

The intent of the project is to use the collected data to create a scale for classifying road surface noise. Two scales are expected to emerge – for low-noise pavements and for conventional surfaces. The scales will be analogous to the other variable parameters and will be numerically graded from tier 1 (lowest noise value) to tier 5 (highest noise value). The work has not yet been completed and the details of the scales are still being worked on.

5. ACKNOWLEDGMENTS

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