ASSESSMENT OF THE TRAFFIC NOISE ON THIN LAYERS

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Traffic noise is an important branch of the environment pollution which deeply affects the population and for that reason it has been included in the set of pavement performance indicators. Nevertheless, the knowledge on the environmental impact of the existing surface pavement layers is very limited, particularly for what respects to tyre/road noise of thin layers. These layers are at the present time widely used in a great extent with rubberized asphalt both in urban and rural roads especially in the north of Portugal due to environmental concerns. In this paper the comparison of the tyre/road noise (*Lmax*) generated in roads with thin surface layers is made. The noise levels generated by light and heavy vehicles are set according to the Statistical Pass-By Method (SPB) of which test methods is described in the standard ISO 11819-1:1997. At management level the information provided by tyre/road noise tests is essential to support environmentally sustainable construction and maintenance alternatives. Furthermore, at project level, the results give some insight about the relation surface layers/traffic composition.

key words: *traffic noise, thin layers, noise limits, test methods*

1. Introduction

Traffic noise is an important branch of the environment pollution which deeply affects the population and for that reason it has been included in the set of pavement performance indicators. Nevertheless, the knowledge on the environmental impact of the existing surface pavement layers is very limited, particularly for what respects to tyre/road noise of thin layers.

The noise produced by the tire/road surface contact is the predominant noise source when considering speeds above 40 to 50 km/h [1]. The tire/road surface noise generation mechanisms derive from radial and tangential vibrations of the tire tread as a result of the impact and the adhesion of the treads on the surface along with air vibrations around the tire and in the grooves and cavities of its treads. These mechanisms may be amplified by the horn effect and by the acoustical and mechanical impedance of the surface [2], which are affected by the following parameters:

Surface characteristics - aggregate gradation, texture, porosity, age, surface stiffness, distresses;
Vehicles - type of vehicle, tire and speed;
Weather conditions - wind, temperature, water on the surface;
Drivers' behaviour.

The thin layers are at the present time widely used as wearing course both in urban and rural roads either in road rehabilitation or in new roads. Especially in the north of Portugal, these thin layers incorporate in great extent rubberized asphalt due to environmental concerns and to their higher structural strength.

Several studies carried out in roads with different types of surface and age have usually shown that dense asphalt concrete, stone mastic asphalt and surface dressings are the ones that generate more noise contrasting with double and single porous asphalt, thin layers and poro-elastic surfaces [3] [4] when the surface is dry. In Portugal, studies were carried out under controlled traffic conditions, according to the Controlled Pass-By Method (CPB). They have shown that thin surface layers have the best performance with respect to noise reduction for light vehicles [5] [6].

In this paper the comparison of the tyre/road noise (*Lmax*) generated in roads with thin surface layers submitted to maintenance is made using the Statistical Pass-By Method (SPB) [7]. The most important advantage of this method is the assessment of tyre-road noise under normal traffic conditions. In this way the complete traffic spectrum which regards a specific road is considered.

2. Testing and analysis methodology

The study was carried out on 9 surfaces using the Statistical Pass-By Method (SPB) [7]. The SPB method relies on a roadside measurement of the maximum A-weighted sound levels (L_{Amax}) on a statistical selection of cars and heavy vehicles passing-by.

A microphone was positioned at 1.2 m above the pavement surface and 7.5 m from the centre of the carriageway.

When possible, the noise was measured in both lanes simultaneously using two microphones.

A set of parameters related to the linear regression analysis of sound pressure levels on speed using data pairs consisting of the maximum A weighted sound level (L_{Amax}) versus the logarithm (base 10) of speed (v) for each vehicle pass-by is calculated. Based on these parameters, the sound levels of the light and the heavy vehicles were calculated at three reference speeds (L_{ref}) in order to facilitate the analysis of the results. The choice of the reference speeds took into account the legal speed limits, the average speeds practiced in each road and speed ranges. The sound levels were not corrected due to temperature variation.

This analysis procedure was used instead of the one recommended at the ISO 11819-1:1997 standard where the behavior of each layer is assessed by means of an index which is the Statistical Pass-By Index (SPBI). For the calculation of this index it is necessary to have a minimum number of vehicles for the following vehicle categories:

Category 1 (cars) – 100;
Category 2a (dual-axle heavy vehicles) – 30;
Category 2b (multi-axle heavy vehicles) – 30;
Categories 2a and 2b together (heavy-vehicles) – 80.

Because traffic composition is notably different from site to site it was not possible to accurately calculate the SPBI.

3. Surface characteristics

The surfaces chosen are identified by an acronym and are described in Table 1. Among the 9 surfaces there are 5 thin layers, those with aggregate size inferior to 12 mm. The others were selected for comparison purposes and are used as reference surfaces.

Few surfaces were tested in both directions, therefore they were identified by an additional number, for example the layer GGAR10-m is identified below by GGAR10-m1 and GGAR10-m2.

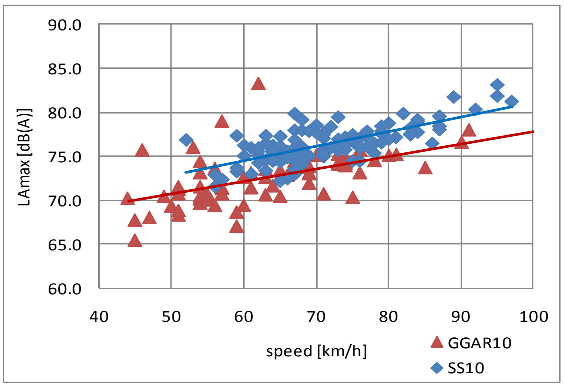
Table 1 – Type and main characteristics of the surfaces tested

Surface	Description	Max. aggregate size [mm]	Age [years]
GGAR10-m	Gap Graded Asphalt Rubber (about 10% rubber over binder weight)	10	1
GGAR10-A	Gap Graded Asphalt Rubber (about 20% rubber over binder weight)	10	4
GGAR10-B	Gap Graded Asphalt Rubber (about 20% rubber over binder weight)	10	-
GGAR12	Gap Graded Asphalt Rubber (about 20% rubber over binder weight)	12	4
PA16	Porous Asphalt	16	5
DA16	Dense Asphalt	16	1
OGA15	Open Graded Asphalt	15	5
SS10	Slurry Surfacing	10	2

OTRA16	Open texture rubber asphalt	16	3

4. Analysis of the results and discussion

For the analysis of the results the following aspects were considered: a) because data dispersion is important, as can be observed in Figure 1, three reference speeds were chosen in order to more accurately assess layers' performance with speed. The reference speeds were set at 50, 70 and 90 km/h for light vehicles and 50 and 70 km/h for heavy vehicles; b) the speed of 50 km/h was not considered in the analysis for the PA16 and OGA15 surfaces because they are in high speed roads; c) the minimum number of vehicles in a specific category considered for the statistical analysis was 5.



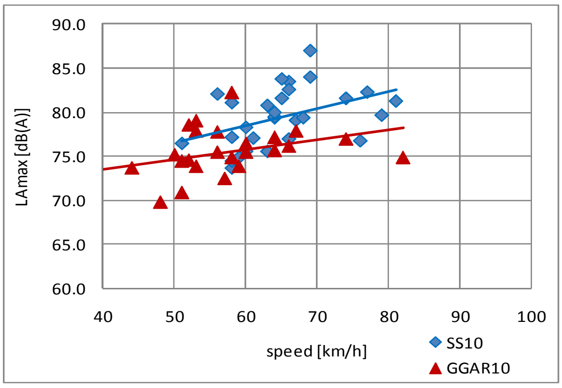


Figure 1 – Example of data results for light (left) and L2a type heavy vehicles (right)

4.1. Noise level versus speed

The slope of the curve sound level (L_{Amax}) versus the logarithm (base 10) of speed (v) is a parameter which indicates the growth of noise with speed. As shown in Figure 2, most of the surfaces tested have slopes between 15 and 30 dB(A)/$\log_{10}$(km/h), although there are much higher values either positive or negative. This parameter seems to be influenced by the type of vehicle. With respect to light vehicles, thin layers seem to have a superior impact with the speed increase.

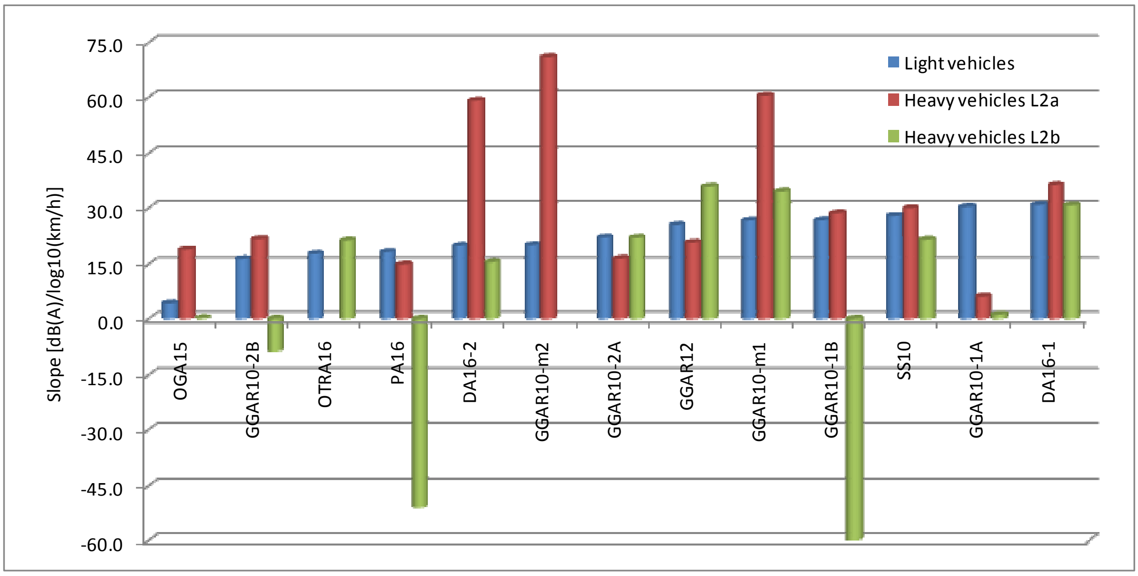


Figure 2 – Slope of the curve LAmax versus log10 of speed for heavy and light vehicles

4.2. Noise levels at reference speeds for light vehicles

Figure 3 shows the calculated LAmax from regression parameters for light vehicles at 50, 70 and 90 km/h. The pairs (LAmax, surface) were ordered increasingly for the speed of 70 km/h in order to facilitate de analysis. The results indicate that new thin layers with negative texture, such as GGAR10-m, have the best performance while new thin layers with positive texture (SS10) and layers with high maximum chipping size provide higher noise levels. Between these layers are placed the dense asphalt (DA16) and the porous asphalt (PA16) which limit a group of thin layers about 5 years old.

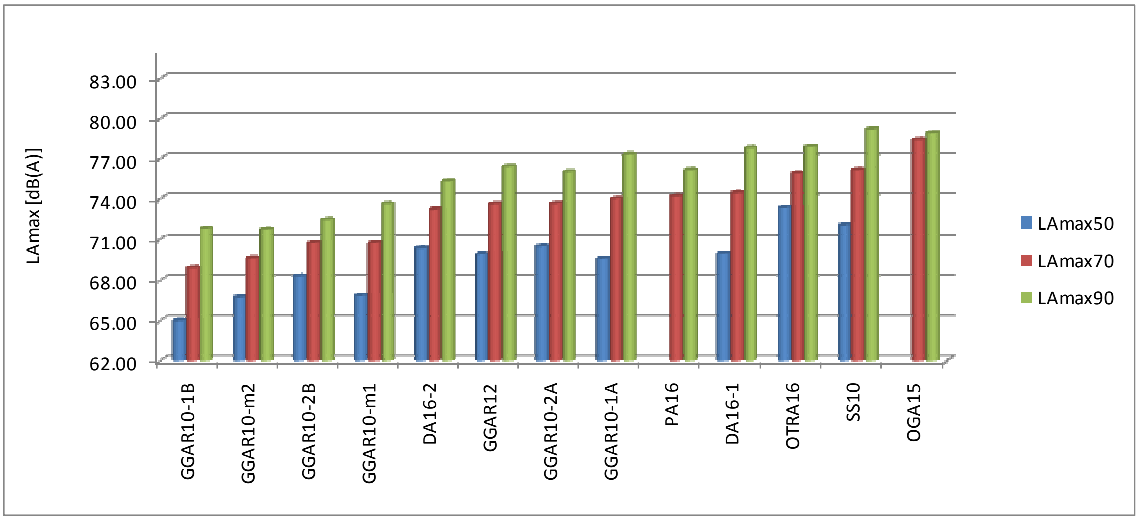


Figure 3 – Calculated LAmax from regression parameters for light vehicles at 50, 70 and 90 km/h

4.3. Noise levels at reference speeds for heavy vehicles

Figure 4 shows the calculated LAmax from regression parameters for heavy vehicles at 50 and 70 km/h, ordered increasingly for the speed of 50 km/h. As expected the noise for the L2b vehicle type is considerably much higher than for the L2a. For these vehicles the noise provided by the thin layers do not have a particular position. It means that the resulting noise levels are either high or low. In this case the variation of the noise level with speed is very sensitive as shown previously (Figure 2) and therefore the performance of the layers.

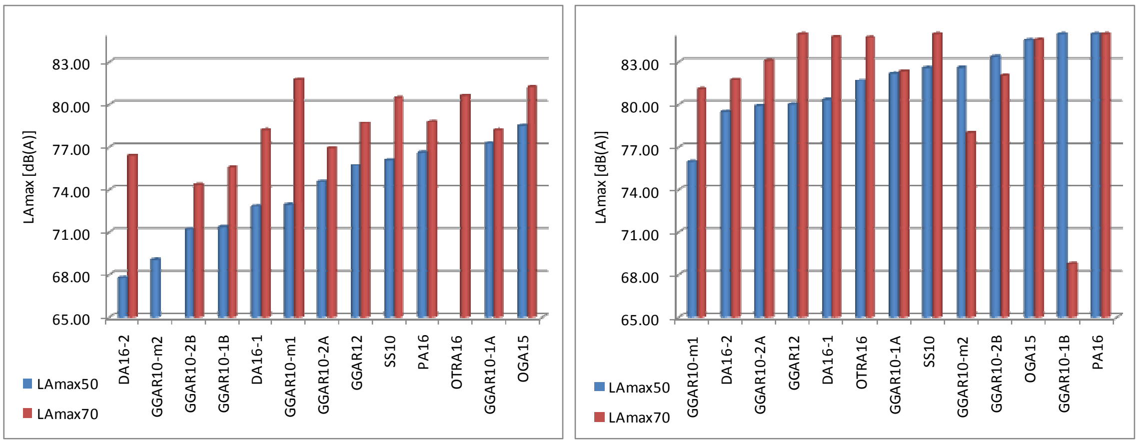


Figure 4 – Calculated LAmax from regression parameters for heavy vehicles at 50 and 70 km/h (L2a – left, L2b – right)

4. Conclusions

The impact of the tyre/road noise of the surface pavement layers is at the present time little known. For that reason in this paper 9 pavement surface layers were assessed in what respects to tyre/road noise using the Pass-By Method. Because thin layers are reported as having a good performance and in Portugal this type of layers are widely used, emphasis was given to them. The analysis of the results addressed the noise level versus speed and the noise levels at reference speeds (50, 70 and 90 km/h) for light and heavy vehicles. The following conclusions may be drawn:

The noise produced by light and heavy vehicles depends differently on speed. Thin layers seem to have a greater impact with speed increase;

For light vehicles, thin layers have generally the best performance except for the one with positive texture (SS10);

For heavy vehicles, any consistent conclusion may be drawn since thin layers have a similar behaviour to the thicker ones and provide both low and high noise levels.

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